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FORTY-SIXTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER COMPANY

ON

BATTALION ANTI-TANK PROJECT

UNDER

Contract No. DA-33-019-ORD-1202

ORDNANCE DEPARTMENT PROJECTS

TS4-4020—WEAPONS AND ACCESSORIES

TM1-1540—AMMUNITION

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COPY No. 50

THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

MAY 1954

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FORTY-SIXTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-019-ORD-1202

RAD Nos. ORDTS 3-3955
ORDTS 3-3957
ORDTA 3-3952

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio

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ABSTRACT

BAT 90mm Projectile - After developing a suitable charge, ten BAT 90mm folding fin type projectiles were fired for accuracy at 1000 yards. The projectiles appeared to fly well but the dispersion was large suggesting that the stability of this design of the projectile may be marginal.

The body and ogive were cemented together and there was no indication either in flight or on the target that the union had failed.

T171 Projectile - Two new T171 projectile modifications having 2 and 2.5 caliber ogives are illustrated. It is believed that the longer ogives will result in a flatter trajectory and shorter time of flight.

The static stability and drag coefficients were calculated for the E12 (2 caliber ogive) and the E13 (2.5 caliber ogive) modifications and are presented here. The static stability of the E12 and E13 models were found to be comparable to the E10 modification and it is concluded that the slow roll imparted by the nylon obturator will be sufficient for dynamic stability.

Ten T171E10 projectiles were fired for accuracy at 2000 yards. The seven rounds which hit the target (three expended in getting on target) gave probable errors of dispersion of $\pm$.36 mil vertically and $\pm$.35 mil horizontally.

Ten T171E12 projectiles were fired for accuracy at 1000 yards. All ten rounds hit the target with probable errors of dispersion of $\pm$.29 mil vertically and $\pm$.24 mil horizontally.

Two T171 test slugs were fired at low temperatures (-60°F) to determine the effect of low temperatures on the spin-inducing qualities of the nylon obturator. The spin measured on one round was 12 rps which would be satisfactory for stable flight. The pop-out pins did not function on the second round.

T120 Projectile - A discussion is given of bearing systems and lubricating films for bearing systems for double body projectiles. Both static and dynamic tests were conducted with modified Lube-Lok coating on DRA218-DRA215 bearing systems. In each case the modified coating showed reduced coefficients of friction.

Fifteen T138E57 type projectiles with and without sleeves (to provide added clearance for penetration) were fired for accuracy at a 478 ft target. The data show that the accuracy of these projectiles at 500 ft is adequate to permit their use as carriers in dynamic tests of fluted cones.

Penetration Studies - Tests were conducted to determine the effect of spin and cone wall thickness on the performance of machined 2S-F aluminum cones at both ordinary projectile standoff of 7.5 in. and at optimum standoffs (for the aluminum cones) of 42 in. and 48 in. The data are presented.

Tests were conducted to determine the penetration efficiency of a heavy apex copper cone. The cone design is illustrated and the inspection and penetration data are presented. The average penetration is higher than for the controls at 7.5 in. standoff and it appears that the design of the apex aids the cone collapse mechanism.

Fuzes - The data are presented for a series of tests to study the sensitivity of "potted lucky" nose elements. The various phases of the study, the conditions of firing, and the results are presented in this report.

BAT 90 MM. PROJECTILE

Folding Fin Projectile

A new design of the BAT 90mm folding fin projectile, shown in Fig. 1, has been fired for accuracy at 1000 yards. This design is similar to the E4 modification shown on page 5 of the Forty-Third Progress Report with the exception that a 2.5 caliber ogive was used instead of the 3.0 caliber ogive.

Charge Development

A charge establishment firing was conducted prior to the accuracy firing. The range data are shown in Table I.

Although the recoil unbalance of the gun for the establsihed charge was excessive, it was decided to proceed with the accuracy program on the supposition that any jump in the gun would result in the same effect on all of the projectiles.

1000-Yard Accuracy Test

Ten BAT 90mm projectiles of the type shown in Fig. 1 were fired for accuracy at an 18 ft by 18 ft target at 1000 yards. The range data are presented in Table II. The projectiles appeared to fly well and a minimum of yaw was recorded on the target. Probable errors of dispersion for ten impacts were $\pm.83$ mil vertical and $\pm.81$ mil horizontal.

The large dispersion of this group indicates the marginal stability of this design of the BAT 90mm folding fin projectile. This marginal stability may have resulted from shortened fins and tapered tail section,introduced in an attempt to reduce the drag.

Another factor which may have affected the accuracy was the excessive recoil of the gun. This recoil unbalance will be corrected before another accuracy program is conducted.

The projectile design fired in this accuracy program had a body with a thinner wall (approx. .135 in.) than any previously fired projectile. The body and ogive were cemented together with plastic bonding agent Shell Epon Adhesive VI (see pages 3 and 4 of the Forty-Fifth Progress Report). There was no indication in the flight or on the target that either the body or the union had failed.

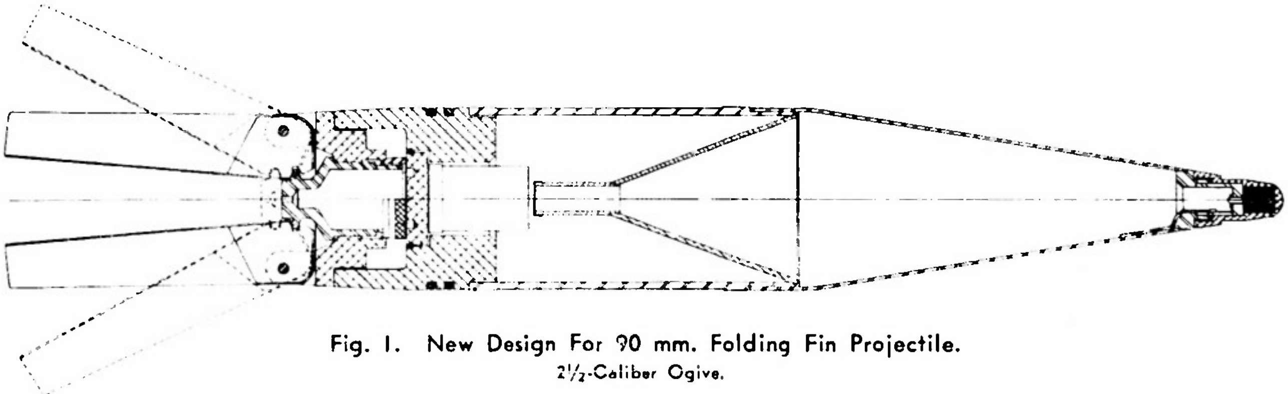


Fig. I. New Design For 90 mm. Folding Fin Projectile.
2½-Caliber Ogive.

Future Program

1. Forty E2 projectiles are being assembled and 20 will be fired for accuracy at 1000 yards and 20 for accuracy at 2000 yards.

2. Low temperature tests of the fin opening mechanism will be conducted.

Table I
Range Data
Charge Development
For 90 mm. BAT Folding Fin Projectile

Sheet __ of __

Date of Test MAY 24, 1954

Location Erie Ordnance Depot

Purpose of Test CHARGE DEVELOPMENT & BALLISTIC INFORMATION

PROJECTILE

Model BAT 90mmE1, TEST SLUG ORC 669
Type FOLDING FIN
Weight 90mmE1 (Nom. 10.5 lb
C.G. Location —
Bourrelet Dia 3.537 -.002
Retard. Factor .180 ft/sec/ft
Special Features E1 Projectiles Loaded to 10.5 lb (Nom.)

TEST GUN

Model 90 MM BAT
Type Recoilless
Serial No. 1
Chamber 134982-2
Bushing(Vert) 32C-226-P (0° Flow Ring)
Tube B-4943-11 (Smooth Bore)
Sighting Equip —
Mount:
Type Pendulum Ser. No __
Constant 2.83 lb/sec/in
Firing Mech —

MISCELLANEOUS DATA

Range Down Range
Propellant:
Type M5MP Web .040 in Weight Varied
Lot No. RAD 16915
Primer M-57
Shell Case T53E1
Liner T6
Temperatures:
Magazine
Max. — Min. — Present —
Loading Room — Ambient —

Round Number	Proj. Number	Proj Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.	Recoil Momentum lb-sec	Type Flow Ring	Observations
7240-1	Slug	11.96	7-11	18,300 / 17,500	2390	2405								24.8 R	0°	1
7241-2	"	11.96	7-11	18,300 / 16,900	—	—								28.3 R	0°	2 Flow Rings Proofed.
7242-3	47	10.37	6-14	12,600 / 13000	2382	2397								29.0 R	0°	3
7243-4	13	10.35	6-14	12,800 / 12,200	2346	2361								28.3 R	0°	4
7244-5	48	10.36	7-0	13,600 / 13,500	2409	2424								19.8 R	0°	5
7245-6	8	10.36	7-0	12,700 / 12,700	2351	2366								31.1 R	0°	6
7246-7	46	10.36	7-2	13,100 / 14,100	2406	2421								31.1 R	0°	7
	ROUNDS BELOW FIRED MAY 26, 1954 TO TEST OUT 10° FLOW RING.															
7265-8	Slug	11.95	6-13	12,500 / 13,200	—									39.7 F	10°	8 Mouth of case was 1.3 in. from rear bourrelet.
7266-9	Slug	11.96	6-13	11,800 / 14,000	—	—								39.7 F	10°	9

Muzzle ├—— 51.79' ——┼—— 59.67' ——┤2

Screen (Coil) Distances

Program Director M. Manofsky

Table II
Range Data
To Test Accuracy Of BAT 90 mm. Folding Fin Projectile

Sheet 1 of 2

Date of Test May 26, 1954
Location Erie Ord Depot

Purpose of Test Accuracy Test of BAT 90mm. Projectiles

PROJECTILE

Model —
Type BAT 90mm Exk
Weight 10.516 (Nom)
C.G. Location 5.60 in
Bourrelet Dia 3.537 +.002 −.00
Retard. Factor
Special Features DRC-15-813 Ogive & Leading Edge, Fins 5.9 in long

TEST GUN

Model BAT 90mm
Type 90mm Recoilless
Serial No. 1
Chamber B4982-2
Bushing(Vent) 32-5-276-P / 2-438-1
Tube B4403-11
Sighting Equip Elbow Telescope T166E1; Bore Sight, Gunners Quadrant, M1
Mount:
Type T52E7 Ser. No —
Constant —
Firing Mech —

MISCELLANEOUS DATA

Range 990 yd.
Propellant:
Type M5 MP Web .040 in Weight 716 3oz
Lot No. RAD 16415
Primer M57
Shell Case T53E1
Liner T6
Temperatures:
Magazine
Max. — Min. — Present 78°F
Loading Room 69°F Ambient 63°F

Round Number	Proj. Number	Proj Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit (mils) Vert.	Corrected Posit. of Hit (mils) Horiz.	Yaw at Target (in)	Wind Vel & Dir. mph deg	Observations
7267	—	—	—	12900	—	—	—	—	—	—	—	—	—	—	—	Warm up round
				12300												
7268	55	10.52		14100	2396		+2	7.7	12.0	+56	+3½	-1.43	-90	3¼x3½	11-050	Flight not observed
				14100	2365											
7269	52	10.53		13700	2384		+2	7.7	12.0	+95	+30	-.33	-.16	3¼x3½	14-075	Good flight
				14100	2357											
7270	60	10.50		14100	2380		+1	7.7	9.0	-46	+9	-1.29	+.25	—	14-060	Flight not observed
				13700	2748											
7271	57	10.51		12800	2430		+1	7.7	9.0	-80½	+5½	-2.37	+.15	3½x3½	14-060	Good flight
				15700	2396											
7272	51	10.50		13700	2389		0	7.7	9.0	+38	-80	+2.07	-2.24	3¼x3¼	16-055	Good flight
				14000	2359											
7273	58	10.54		13900	2362		+1	7.7	9.0	-24	+45½	-.67	+1.28	3⅝x3⅝	14-050	Good flight
				14100	2334											
7274	59	10.52		14300	2337		+1	7.7	9.0	+4	+17½	+.11	+.49	3¼x3¼	12-060	Good flight
				14100	2334											
7275	56	10.56		14200	2369		+1	7.7	9.0	-49½	+60	-1.39	+1.68	3½x3½	13-065	Good flight
				13800	2337											
7276	53	10.54		13900	2368		+1	7.7	9.0	-116	+10	-3.25	+.28	—	5-065	Hit below target
				13500	2334											
7277	54	10.53		13600	2367		+1	7.7	9.0	-19	-86½	-.55	-2.43	3¼x3½	15-075	Good flight
				12500	2334											

Muzzle — 29.29' — 1 — 48.21' — 2 — 39.99' — 3 — 39.59' — 4
Screen (Coil) Distances

Center of Impact -1.01 V; -.064 H (mil)
Probable Error:
Vertical (mils) ± .83
Horizontal (mils) ± .81

Proof Director E. Huffman
Observers L. P. Swoebly

Program Director M. Monofsky

Table II (Cont.)

Sheet 2 of 2

Date of Test May 26, 1954
Location Erie Ord Depot

Purpose of Test Test Accuracy of BAT 90mm. Projectiles

PROJECTILE
Model BAT 90mm.
Type E4X
Weight
C.G. Location
Bourrelet Dia.
Retard. Factor
Special Features

TEST GUN
Model BAT 90mm.
Type 90mm Recoilless
Serial No.
Chamber
Bushing(Vent)
Tube
Sighting Equip.
Mount:
Type ______ Ser. No.
Constant
Firing Mech.

MISCELLANEOUS DATA
Range 990 yd.
Propellant:
Type ____ Web ____ Weight ____
Lot No.
Primer
Shell Case
Liner
Temperatures:
Magazine
Max. ____ Min. ____ Present ____
Loading Room ____ Ambient ____

Round Number	Proj. Number	Orifice (in.)	Runout of Nose	Stop-Dia (Knurl) (in.)	C.G. (in.)	Counterbore Dia. Inside	Counterbore Dia. Outside	Fin Opening at Target (in.)		Observations
1	51	.119	.010	1.5675	5.59	1.551	1.5475	7⅞ x 7⅞ x 7⅞	1	
2	52	.120	.011	1.568	5.60	1.5535	1.5555	7⅞ x 7⅞ x 7⅞	2	
3	53	.120	.013	1.568	5.60	1.5515	1.5535	Below target	3	
4	54	.119	.012	1.568	5.62	1.556	1.558	7⅞ x 7⅞ x 7⅞	4	
5	55	.119	.014	1.5686	5.59	1.5515	1.553	7⅞ x 7⅞ x 7⅞	5	
6	56	.119	.010	1.5655	5.60	1.5515	1.5535	7⅞ x 7⅞ x 7⅞	6	
7	57	.119	.012	1.569	5.59	1.5525	1.552	8 x 8 x 8	7	
8	58	.119	.009	1.568	5.60	1.551	1.562	7⅞ x 7⅞ x 7⅞	8	
9	59	.118	.011	1.567	5.60	1.5515	1.553	7⅞ x 7⅞ x 7⅞	9	
10	60	.120	.009	1.568	5.60	1.5515	1.5532	7⅞ x – x –	10	
11									11	

No Piezo plug for rounds 7274 & 7275. Bolt replaced before round 7276, blew out on round 7277

No yaw cards used, measurements taken from target for fin openings

Retardation and Time of Flight attempted, but results were inconclusive

Center of Impact -1.01V; -.06H(mil)
Probable Error:
Vertical (mils) ± .83
Horizontal (mils) ± .81

Proof Director E. Huffman
Observers L. P. Swoebly
Program Director M. Menefsky

Projectile Designs

Two new T171 projectiles, designated the E12 and the E13, have been designed. Both of these projectiles use the same body and tail as the T171E10 projectile; the 1.5 caliber ogive of the E10 is replaced with a 2.0 caliber conical ogive to make the E12, and with a 2.5 caliber conical ogive to make the E13 configuration. These configurations, and their component parts, are shown in Table III.

The increased ogive length will serve to reduce the drag force acting on the projectile, resulting in a flatter trajectory and a shorter time of flight. Thus, the effect on accuracy of variations in range estimation, sighting of the weapon, and muzzle velocity should be less for these two rounds than for the T171E10 projectile.

The penetration potential with the T171 round should be improved by the use of a longer ogive, since the optimum standoff for maximum penetration is greater than 1.5 calibers for this type of round.

Table III
T171 Projectile Types
Components Of E10, E12 and E13 Modifications

Type	Pictures	Component Parts	Drawing No.
T171E10		1 1/2 caliber conical nose Body 6-Finned, End Plated Tail	DRB183-1 DRC193-4 DRC132-3
T171E12		2 caliber conical nose Body 6-Finned, End Plated Tail	DRB-14-951 DRC193-4 DRC132-3
T171E13		2 1/2 caliber conical nose Body 6-Finned, End Plated Tail	DRC-14-778 DRC193-4 DRC132-3

Stability

A normal force coefficient, restoring moment coefficient, and center of pressure were estimated for the T171E10 configuration, using T131 projectile wind tunnel data (BRL TN 565, Wind Tunnel Tests of the T131, 105mm HEAT Projectile, by R. H. Krieger). Assuming that

$$K_M = K_N(CP-CG) = \left[K_N(CP-CG)\right]_{\text{Nose-Body}} + \left[K_N(CP-CG)\right]_{\text{Tail}}$$

the normal force and restoring moment coefficients and center of pressure of component parts of the T131 projectile were found. Applying this information to the T171E10 configuration, values of normal force and restoring moment coefficients, and centers of pressure were determined.

The normal force coefficient and center of pressure for the 1.5, 2 and 2.5 caliber conical ogives were calculated by Tsien's equations,

$$K_N = \frac{\pi}{4}\,\frac{n\sqrt{n^2-1}}{\cosh^{-1}n + n\sqrt{n^2-1}}$$

$$CP = \frac{2\ell}{3}$$

where

$$n = \frac{\cot\theta_s}{\sqrt{M^2-1}}$$

θ_s = semi-cone angle

M = Mach number

ℓ = distance from vertex to base of cone.

If the difference in these aerodynamic coefficients and centers of pressure for these three configurations results only from the difference in the aerodynamic coefficients and centers of pressure of the three ogives, the normal force and restoring moment coefficients and centers of pressure for the E12 and E13 can be estimated. These data are tabulated in Table IV.

These estimates indicate that the static stability of the E12 and E13 projectiles is comparable to that of the T171E10. The slow roll imparted to the T171 rounds by the nylon obturator, DRA-14-1281, shown in Fig. 2 should be sufficient to provide dynamic stability for both designs.

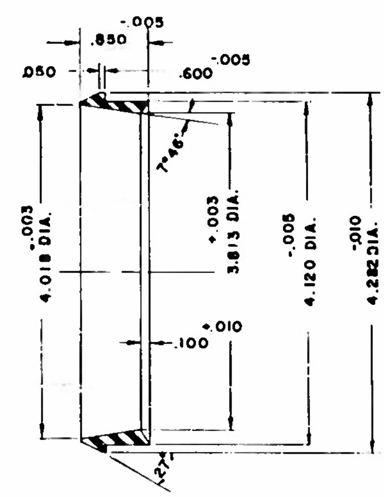


Fig. 2. Nylon Obturator.
Firestone Drawing No. DRA-14-1281.

Table IV
T171 Projectile Aerodynamic Data
At Mach 1.72

Type	K_M	CP−CG (cal.)	K_N	K_D	$i_{7.2}$
E10	-.720	-.471	1.530	.233	1.85
E12	-.670	-.417	1.606	.196	1.57
E13	-.828	-.505	1.640	.190	1.52

Drag Function

The drag force coefficients for the E12 and E13 projectiles have been estimated on the assumption that the decrease in drag (from the T171E10) is due entirely to the difference in drag force on the conical ogives. Drag coefficients for the 1.5, 2 and 2.5 caliber ogives were calculated using the equation of Karush and Critchfield (The Drag Coefficient for a Cone Moving with High Velocity, NDRC, Armor and Ordnance Report No. A-126), where

$$K_D = .7854 \frac{P_s}{\rho u^2}$$

where

P_s = surface pressure on cone

u = velocity of cone.

ρ = air density

The drag coefficients for the E12 and E13 configurations at Mach 1.72 were obtained by adding the difference in drag coefficients of the cones to the value of the drag coefficient of the T171E10 given in Fig. 16, Thirty-Seventh Progress Report. The form factors, based on Type 7 projectile, were then calculated for the E12 and E13 configurations. These data are tabulated in Table IV also.

Accuracy Tests

T171E10 At 2000-Yard Range

Ten T171E10 projectiles were fired for accuracy at Erie Ordnance Depot. These projectiles were equipped with nylon obturators, DRA-14-1281, and placed in the shell case as shown in Fig. 25, Forty-First Progress Report. A T19 rifle, with a 1-20 twist tube was used for this program. The target was placed approximately 2000 yards from the muzzle. The firing record for this program is shown in Table V.

Three rounds were expended in getting on the target. The remaining seven rounds hit the target with probable errors of ± .36 mil vertically and ± .35 mil horizontally. This group of rounds, fired at an average muzzle velocity of 1690 fps, with 62 mils elevation and 2 mils right azimuth, had a center of impact .82 mil below and .50 mil to the right of the aiming point. The target plot for this firing is shown in Fig. 3.

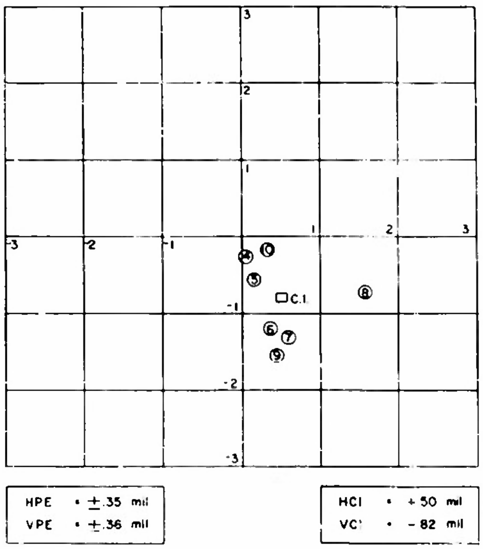


Fig. 3. Target Plot.
T171E10 Projectile At 2000 Yards.

Table V
Range Data
To Determine Accuracy and Flight Characteristics T171E10 Projectile

Sheet 1 of 2

Date of Test April 30, 1954
Location Erie Ord. Depot

Purpose of Test To Determine Accuracy & Flight Characteristics of T171E10

PROJECTILE

Model T171
Type E10
Weight 17.5 lb. (Nom.)
C.G. Location ——
Bourrelet Dia. 4.132 -.002 in.
Retard. Factor 0.22 fps/ft.
Special Features None

TEST GUN

Model T19
Type 105 mm. Recoilless
Serial No. 6
Chamber 26694-1-12931 (Liner used)
Bushing(Vent) VA884 (7230826)
Tube 12742-2656-2 (1/20 Twist)
Sighting Equip. Bore Sight; Gunners Quadrant, M1
Mount:
Type M75 Ser. No. 541
Constant ——
Firing Mech. Electric

MISCELLANEOUS DATA

Range 2000 yd. Line of fire 2° clockwise from Magnetic North
Propellant:
Type M10 MP Web .035 in. Weight 7 lb 14 oz.
Lot No. PA 30259
Primer M57 (13 in.)
Shell Case T53E1 modif.
Liner T6 Special
Temperatures:
Magazine
Max. 73°F. Min. 71°F. Present 72°F.
Loading Room 69°F. Ambient 78°F.

Round Number	Proj. Number	Proj. Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero/super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.	Yaw at Target (in.)*	Wind Dir & Vel. mph-deg	Observations
7135	64H	17.53	7-14	9500	1656	1671	0	58-600	—	—	—	—	—	7 - 135	Missed target, to left. Piego Gage No. 13
				9100											
				—											
7136	62H	17.53	7-14	9000	1668	1683	2	5.8-60.0	-45	-4	+1.377	-0.055	12x4	8 - 125	Hit 51 ft short & 6.9 ft. right of center
				8900											
				(P)10,540											
7137	57H	17.54	7-14	9200	1664	1679	2	5.8-63.0	—	—	—	—	—	10 - 120	Missed, over top
				9200											
				(P)10,650											
7138	60H	17.54	7-14	9200	1678	1693	2	5.8-62.0	-19	0	-0.263	0.000	8½x4	5 - 165	
				9500											
				(P)10,640											
7139	55H	17.54	7-14	9700	1685	1700	2	5.8-62.0	-42	+11	-0.581	+0.152	No A.Y.	8 - 190	Changed Piego Gage after this round, to No. 16
				9700											
				(P)11,430											
7140	61H	17.54	7-14	9900	1669	1684	2	5.8-62.0	-86½	+27	-1.197	+0.374	No A.Y.	9 - 150	
				9500											
				(P)10,900											
7141	58H	17.54	7-14	9400	1669	1684	2	5.8-62.0	-91½	+42	-1.266	+0.581	No A.Y.	9 - 165	Misfire, cap reversed. Replaced and fired
				9400											
				(P)10,950											

Muzzle —— 45.90' —— 1 —— 41.18' —— 2
Screen (Coil) Distances

Center of Impact -0.815V; +0.498H
Probable Error:
Vertical (mils) ± 0.36
Horizontal (mils) ± 0.35

Proof Director E. Huffman
Observers Drs. Thurman & Ford
L. P. Sweably

Signed W. McMillen

continued on next page

Table V (Cont.)

Sheet 2 of 2

Date of Test April 30. 1954
Location Erie Ord Depot

Purpose of Test To Determine Accuracy & Flight Characteristics of T171E10

PROJECTILE

Model T171
Type E10
Weight ______
C.G. Location ______
Bourrelet Dia ______
Retard. Factor ______
Special Features ______

TEST GUN

Model T19
Type 105mm Recoilless
Serial No. ______
Chamber ______
Bushing(Vent) ______
Tube ______
Sighting Equip. ______
Mount:
Type ______ Ser. No ______
Constant ______
Firing Mech. ______

MISCELLANEOUS DATA

Range 2000 yd.
Propellant:
Type ______ Web ______ Weight ______
Lot No. ______
Primer ______
Shell Case ______
Liner ______
Temperatures:
Magazine
Max. ______ Min. ______ Present ______
Loading Room ______ Ambient ______

Round Number	Proj. Number	Proj Weight (lb.)	Propell. Weight (lb.-oz)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero/super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.	Yaw at Target (in.)*	Wind Vel & Dir. mph-deg.	Observations
7142 1	56H	17.53	7-14	9900	1682	1697	2	5.8-62	-52	+114	-0.719	+1.577	6x4	12-185	
2				9400											
3				11,000 (P)											
7143 4	59H	17.54	7-14	9300	1662	1677	2	5.8-62	-111½	+32	-1.542	+0.443	No A.Y.	10-175	
5				9500											
6				10,860 (P)											
7144 7	63H	17.54	7-14	9400	1682	1697	1	5.8-62	-10	-46½	-0.138	+0.357	No A.Y.	11-160	
8				9100											
9				10,900 (P)											
10															
Averages				9365 (Cu) 10874 Piezo		1687									

* No A Y = No Appreciable Yaw. All measurements assumed to have Target flat and perpendicular to line of flight. Target actually bowed away from gun during the entire firing period.

(P) indicates Piezo pressures

Muzzle — 45.90' — 41.18' — 2

Screen (Coil) Distances

Center of Impact -0.81 5A, +0.498 H
Probable Error:
Vertical (mils) ± 0.36
Horizontal (mils) ± 0.35

Proof Director E. Huffman
Observers Drs. Thurman & Ford
L. P. Sweebly

Signed W. McMillan

T171E12 At 1000-Yard Range

Ten T171 E12 projectiles were fired for accuracy at Erie Ordnance Depot, from a T19 rifle at a 1000-yard target. These rounds were equipped with nylon obturator DRA-14-1281, and placed in the shell case as shown in Fig. 4. The firing record for this program is shown in Table VI.

All ten rounds hit the target with probable errors of ±.29 mil vertical and ±.24 mil horizontal. This group of rounds, fired with an average velocity of 1691 fps, at 22 mils elevation and 2 mils left azimuth, had a center of impact .87 mil left and .75 mil above the target center. The target plot for this program is shown in Fig. 5.

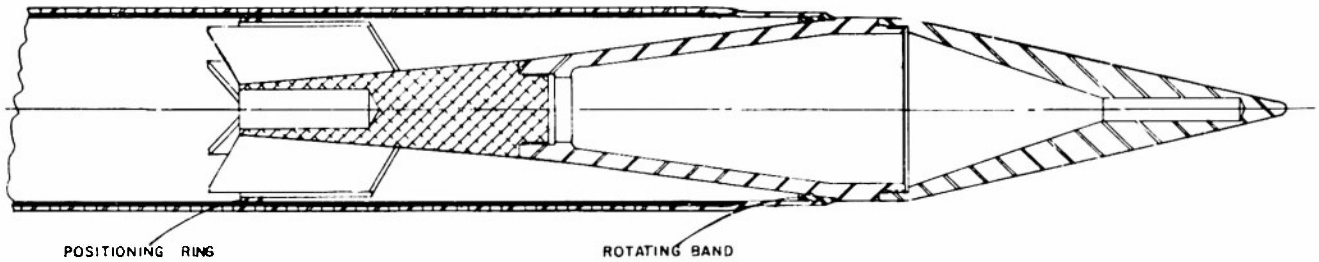


Fig. 4. T171E12 Projectile In Shell Case.

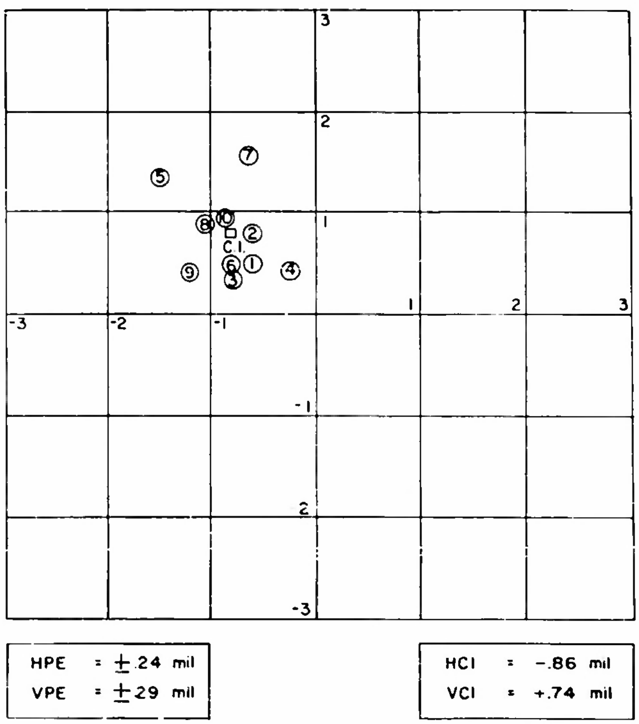


Fig. 5. Target Plot.
T171E12 Projectile At 1000-Yard Range.

Table VI

To Determine Accuracy Of T171E12 Projectile
1000 Yards

Sheet 1 of 2

Date of Test May 21, 1954
Location Erie Ord. Depot

Purpose of Test To determine Accuracy of T171E12

PROJECTILE

Model T171
Type E12
Weight 17.82 lb. (Avg.)
C.G. Location ______
Bourrelet Dia. 4.132 -.002 in.
Retard. Factor 0.23 fps/ft.
Special Features Nylon obturator, Conical Ogive (2 cal)

TEST GUN

Model T19
Type 105mm Recoilless
Serial No. 6
Chamber 26694-1-12931 (Liner used)
Bushing (Vent) VA884 7230826
Tube 12742-2656-2 (1/30 Twist)
Sighting Equip Bore Sight, Gunners Quadrant M1
Mount:
Type M75 Ser. No. 541
Constant ______
Firing Mech. Solenoid

MISCELLANEOUS DATA

Range 1000 yd. (Line of fire 28° clockwise from Magn. N.)
Propellant:
Type M10 MP Web .035 in Weight 7 lb 14 oz.
Lot No. PA 30259
Primer M57 (13 in.)
Shell Case T53E1 mod. f.
Liner T4 (cut off)
Temperatures:
Magazine Max. 73°F Min. 71°F Present 72°F
Loading Room 63°F Ambient 63°F

Round Number	Proj. Number	Proj. Weight (lb)	Time of Flight (sec.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) * Instr.	Muzzle Velocity (fps) * Actual	Azim. (mils)	Elevation (mils) zero | super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.	Terminal Veloc. (fps)	Wind Vel & Dir. mph-deg	Retardation (fps/ft)	Observations
7228	2	17.82	2.05446	9800	—	—	-2	8.6 - 22	+17 1/4	-23 3/4	+0.484	-0.666	1138	4 - 000	—	Good flight. Some yaw in flight
				9900	—	—										
7229	4	17.82	2.06791	9400	1671.8	1685	-2	8.6 - 22	+ 27	-22 1/2	+0.757	-0.631	1178	6 - 355	—	Good flight
				9300	1469.1											
7230	9	17.83	2.06207	9200	1675.9	1689	-2	8.6 - 22	+10 1/2	-29 1/2	+0.295	-0.827	1144	3 - 025	.233	Good flight
				9400	1656.3	1698										
7231	1	17.82	2.06352	9500	1674.7	1688	-2	8.6 - 22	+ 15	- 9	+0.421	-0.252	—	6 - 000	.236	Good flight
				9500	1654.9	1687										
7232	5	17.84	2.04577	9800	1690.0	1703	-2	8.6 - 22	+48 1/4	- 55	+1.353	-1.542	—	3 - 030	.218	Good flight After firing gun 0.9 mil up and 0.8 mil left
				10000	1671.7	1704										
7233	8	17.82	2.05943	9500	1679.4	1692	-2	8.6 - 22	+ 15	- 31 1/4	+0.421	-0.876	1137	4 - 005	.225	Good flight
				9400	1660.5	1693										
7234	7	17.82	1.68868	9700	1678.8	1692	-2	8.6 - 22	+56 1/2	-24 1/4	+1.585	-0.680	—	3 1/2 - 020	.210	Good flight. After firing gun 0.7 mil up and 0.5 mil left
				9300	1661.2	1693										
7235	3	17.82	2.06601	9500	1674.7	1688	-2	8.6 - 22	+30 1/2	-37 1/2	+0.855	-1.052	—	4 - 345	.219	Good flight. After firing gun 0.2 mil up, azim. unchanged
				9600	1656.3	1688										
7236	6	17.81	2.06663	9700	1673.0	1686	-2	8.6 - 22	+14 3/4	-43 1/8	+0.414	-1.213	—	2 - 055	.232	Good flight
				9600	1653.5	1686										
7237	10	17.82	2.10275	9900	1680.6	1694	-2	8.6 - 22	+ 32	- 33	+0.847	-0.926	—	2 - 355	.231	Good flight
				9700	1661.2	1693										

Muzzle — 30.86' — 1 — 48.15' — 2 — 40.12' — 3 — 39.52' — 4
Screen (Coil) Distances

Center of Impact +0.748V; -0.867H
Probable Error:
Vertical (mils) ± 0.29 By RMS
Horizontal (mils) ± 0.24 By RMS

Proof Director E. Huffman
Observers W. C. Davies, L. P. Swaebly
Signed W. McMillan

Table VI (Cont.)

Sheet 2 of 2

Date of Test May 21, 1954
Location Erie Ord. Depot

Purpose of Test To determine Accuracy of T171E12

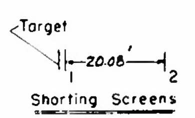
PROJECTILE
Model T171
Type E12
Weight
C.G. Location
Bourrelet Dia.
Retard. Factor
Special Features

TEST GUN
Model T19
Type 105mm Recoilless
Serial No.
Chamber
Bushing(Vent)
Tube
Sighting Equip.
Mount:
Type ______ Ser. No.
Constant
Firing Mech.

MISCELLANEOUS DATA
Range 1000yd.
Propellant:
Type ______ Web ______ Weight
Lot No.
Primer
Shell Case
Liner
Temperatures:
Magazine
Max. ______ Min. ______ Present
Loading Room ______ Ambient.

Gun bore sighted on center of target. M17 Telescope 0.0 azim when bore sight 0.0 azimuth.
Zero difficult to see so sight raised to +10 elev. M17 Telescope -1.0 mil left after
super elevation put on. After firing bore sight on 0, M17 Telescope 0.3 mil left of bore
sight line. Gunners Quadrant at 8.6 mils at +10 mil elevation from target center.
* First reading from Coils 1 and 2, second reading from Coils 3 and 4. All velocities computed with 0.25 fps/ft. Retardation

Round Number	Proj. Number	Proj. Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.			Observations
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14
15																15
16																16
17																17
18																18
19																19
20																20
21																21
22																22



Center of Impact +0.748V; -0.867H
Probable Error:
Vertical (mils) ± 0.29 by RMS
Horizontal (mils) ± 0.24 by RMS

Proof Director E. Huffman Signed W. McMillen
Observers W.O. Davies
L.P. Sweebly

Low Temperature (—60°F) Test

Two T171 test slugs, Fig. 6, were fired to determine the effect of low temperature on the roll inducing qualities of the nylon obturator, DRA-14-1281, and the effectiveness of powder ignition by the modified (13 inch) M57 primer. These rounds were placed in the cold box, set at -60° F, at 11:15 on May 6, 1954, and left there until they were fired at approximately 1:30 P. M. on May 10, 1954. The rounds were fired from the T19 rifle, through a series of five yaw cards, and into a recovery box 180 feet from the muzzle. The firing record for this program is shown in Table VII.

These rounds had an average muzzle velocity of 1493 fps, with an average chamber pressure of 5, 100 psi, indicating that powder ignition by this primer at this temperature is satisfactory. The spin measured on round 1 was 12 rps, which would be satisfactory for stable flight. At 70° F, spin rates of from 11 to 24 rps have been reported previously (Table IX, Forty-Third Progress Report). The pop-out pins on round 2 did not function, either because of a very low spin, or because the pins were frozen to the projectile. The spin data for round 1 are shown on the firing record.

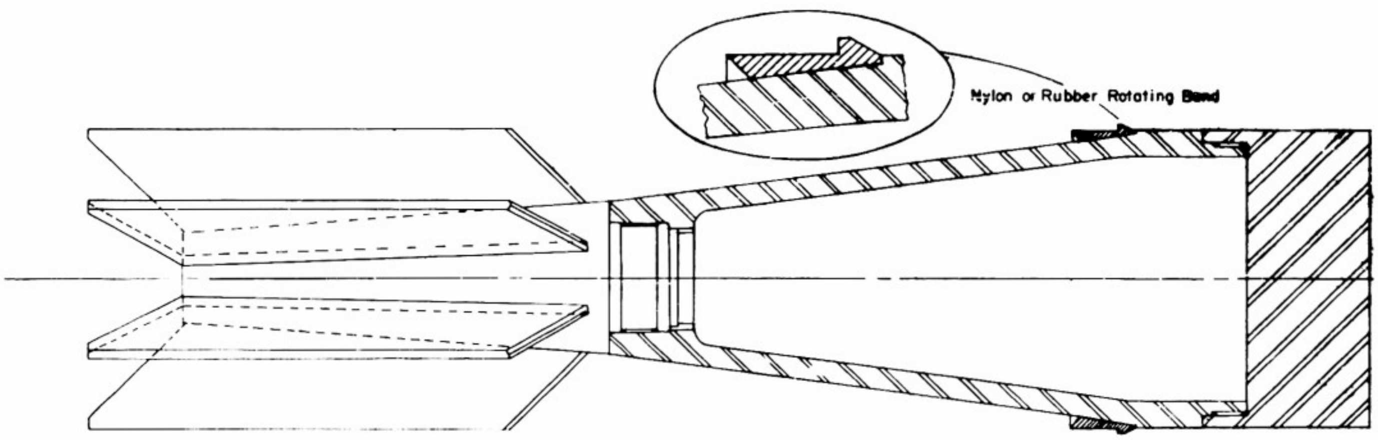


Fig. 6. T171 Test Slug.

Table VII
Range Data
To Test Nylon Band at −60°F

Date of Test 10 MAY 1954
Location ERIE ORDNANCE DEPOT

Purpose of Test TO TEST RELIABILITY OF NYLON BAND AS A SPIN INDUCING DEVICE FOR T171 E10 XB AT -60°F

PROJECTILE

Model T171
Type E10
Weight 17.5 LB. NOM.
C.G. Location
Bourrelet Dia 4.132"
Retard. Factor 0.5-FT/SEC/FT
Special Features POP-OUT PIN, BLUNT NOSE; NYLON BAND

TEST GUN

Model T19
Type 105 MM RECOILLESS
Serial No. 6
Chamber 26694-1-12931
Bushing(Vent) VA 884 (7230826)
Tube #6 12742-2656-2 1-20 TWIST
Sighting Equip. M17 ELBOW TELESCOPE
Mount:
Type OLD PENDULUM
Constant 2.58 LB. - SEC./IN.
Firing Mech. ELECTRIC

CHAMBER LINER USED

AMMUNITION LOADED AS A SINGLE UNIT

MISCELLANEOUS DATA

Range RECOVERY BOX
Propellant:
Type MP M10 Web 0.035" Weight 7LB 14OZ.
Lot No. PA 30259
Primer 13" M57
Shell Case T53E1
Liner DRC-545
Temperatures: °F
Magazine
Max. 73 Min. 71 Present 72
Loading Room 75 Ambient 58

Round Number	Proj. Number	Proj Weight (lb.)	Propell. Weight (lb - oz)	Chamber Pressure (psi) (Cu.) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Spin 1–2	Spin 2–3	Spin 3–4	Spin 4–5	Spin 5–6	Spin Average	Recoil (in)	Cold Box Temperature (°F)	Observations
7167-1	13	17.49	7-14	—	1456	1489	11.7	12.3	12.5	12.3	10.7	11.9	6 1/4"F	-67	1 Vents fully open - Projectile recovered.
				5100											2
7168-2	8	17.48	7-14	-	1464	1497	No pin marks on any card for this round.						7 3/4"F	-64	3 Vents fully open - Projectile recovered.
				5100											4
AVERAGE			7-14	5100	1460	1493							7"F		5 NOTE: 8MM Fastax pictures on both rounds.
															6
															7
	7167-1	Cd. 1	Cd. 2	Cd. 3	Cd. 4	Cd. 5	Cd. 6								8 Rounds placed in Cold Box 1115, 6 May 54. Cold Box set at -60°F.
	ø	18°LP	34°LP	101°LP	106°SP	121 1/2°LP	135°LP								9 It is possible that pin was frozen and did not pop-out due to
	Body	5 5/8 x	5 11/16 x	4 3/4 x	6 3/16 x	6 3/4 x	6 3/4 x								10 low spin on round 7168-2. Both pins were visible on same
	Yaw	4 1/8	4 3/16	4 1/8	4 1/8	4 1/8	4 1/8								11 cards of round 7167-1. Card 3 of 7168-2 had no A.Y. while the
	Θ	349°	352°	327°	196°	17°	15°								12 other five cards showed considerable yaw.
															13
	7168-2														14
	ø	No pin mark on any card													15
	Body	8 x	7 7/8 x	4 1/8 x	7 1/4 x	7 7/8 x	6 7/8 x								16
	Yaw	4 3/16	4 1/8	4 1/8	4 1/8	4 1/8	4 1/8								17
	Θ	40°	50 1/2°	No A.Y.	249°	75°	69°								18
															19
															20
															21
															22

Muzzle ├── 52.30′ ──┼[1]── 59.67′ ──┤[2]
Screen (Coil) Distances

Muzzle ├─ 24′ ─┼[1] 6.02′ ┼[2] 22.28′ ┼[3] 59.67′ ┼[4] 63.05′ ┼[5] 4.99′ ┤[6]
Distances (Yaw Cards) (Spin Screen)

Proof Director EDWARD HUFFMAN

Double Body Projectiles

Various types of bearing systems have been evaluated for the purpose of determining their usability in a double body projectile (Supplements to the Ninth, Thirteenth, Sixteenth, Twenty-Fifth, Twenty-Sixth, Thirty-Fourth, and Thirty-Fifth Progress Reports). It is evident that a double body projectile can operate efficiently only with an adequate bearing system between the two projectile sections. This bearing system must be capable of accepting the thrust load, caused by set-back without developing a large frictional torque. Since the thrust loads developed in the BAT weapon are not unreasonable, studies in this laboratory have been directed toward the development of a bearing system capable of accepting the full thrust load.

Early studies with caged thrust bearings indicated that the bearing cage locked the balls or rollers and prevented proper functioning of the bearings, and that cageless bearings gave consistently better results.

Various pivot bearing designs including spherical, hemispherical, and flat types, incorporating different types of oils, greases, and solid lubricants have been evaluated. Tests have continued and in the latest a DRA 215 and DRA 218 step bearing system coated with Electrofilm Corporation's solid film lubricant Lube-Lok was evaluated and reported in the Supplement to the Thirty-Fourth Progress Report. It should be noted that coefficients of friction of the order of .3 were obtained at low loads for this system, but that with progressively increasing loads the coefficient of friction decreased and was .2 at a bearing pressure of 20,000 psi. Recently Pyrene Manufacturing Company of Newark, New Jersey, suggested a change in the Lube-Lok coating as a possible means of improving the results obtained at low loads and a recent test of the new coating has been completed. For the sake of simplicity in this report, the coating used in the test reported in the Supplement to the Thirty-Fourth Progress Report will be referred to as lubricant No. 1 and the coating used in the current test as lubricant No. 2. (For detailed information on these two coatings see Fig. 8).

Static Tests

Static loads from 500 to 10,000 lbs were applied progressively to the DRA 215-218 bearing system through the testing arrangement shown in Fig. 7. In this test a predetermined load was applied, the torque measured, and the load released, before a succeeding load was applied.

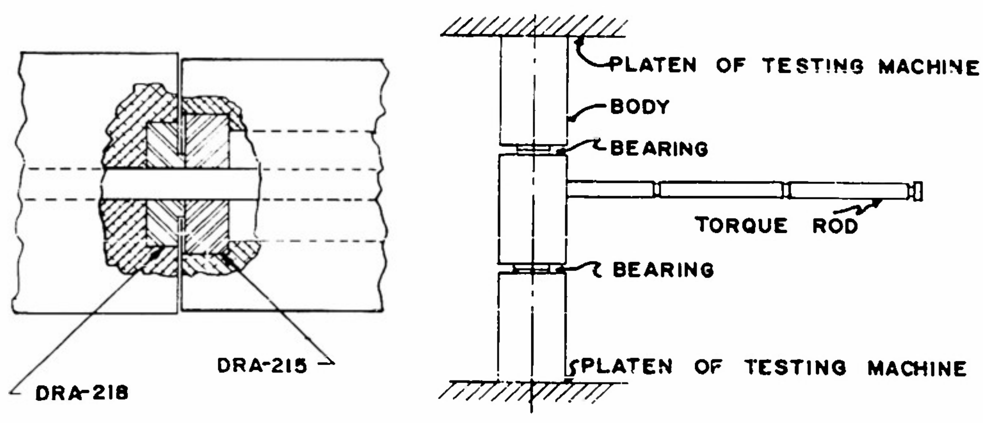


Fig. 7. Bearing System and Static Test Arrangement.

The loads were increased progressively until the limit of the torque wrench was approached. Table VIII gives the results of this test along with those reported for lubricant No. 1. Fig. 8 shows the load torque curve for the DRA 215-218 bearing system with the two lubricants. At all loads above 2000 lbs, lubricant No. 2 developed a torque nearly 200 lb-in less than that of lubricant No. 1. However, in neither case, did the static tests with the Lube-Lok coating approach the results obtained using an excess of molycote, (see Fig. 9).

Table VIII
Static Test Data
DRA215-218 Bearing System

Load (Lb.)	Pull (Lb.)	Torque Arm (In.)	Torque Per Two Bearings (Lb. — In.)	Torque Per Bearing System (Lb. — In.)
Lubricant	Number 1			
250	8	8	64	32
500	16	8	128	64
750	24	8	192	96
1000	31	8	248	124
1500	42	8	336	168
2250	34	14	476	238
2750	42	14	588	294
3050	45	14	630	315
4050	43	18.63	801.1	400.6
5000	50	18.63	931.5	465.8
6000	57	18.63	1061.9	531.0
Lubricant	Number 2			
500	3.0	12	36	18
1000	5.0	12	60	30
3000	14.5	12	174	87
5000	42.0	12	504	252
7000	40.0	18	720	360
8000	53.0	18	954	477
9000	60.0	18	1080	540
10000	46.0	24	1103	551.5

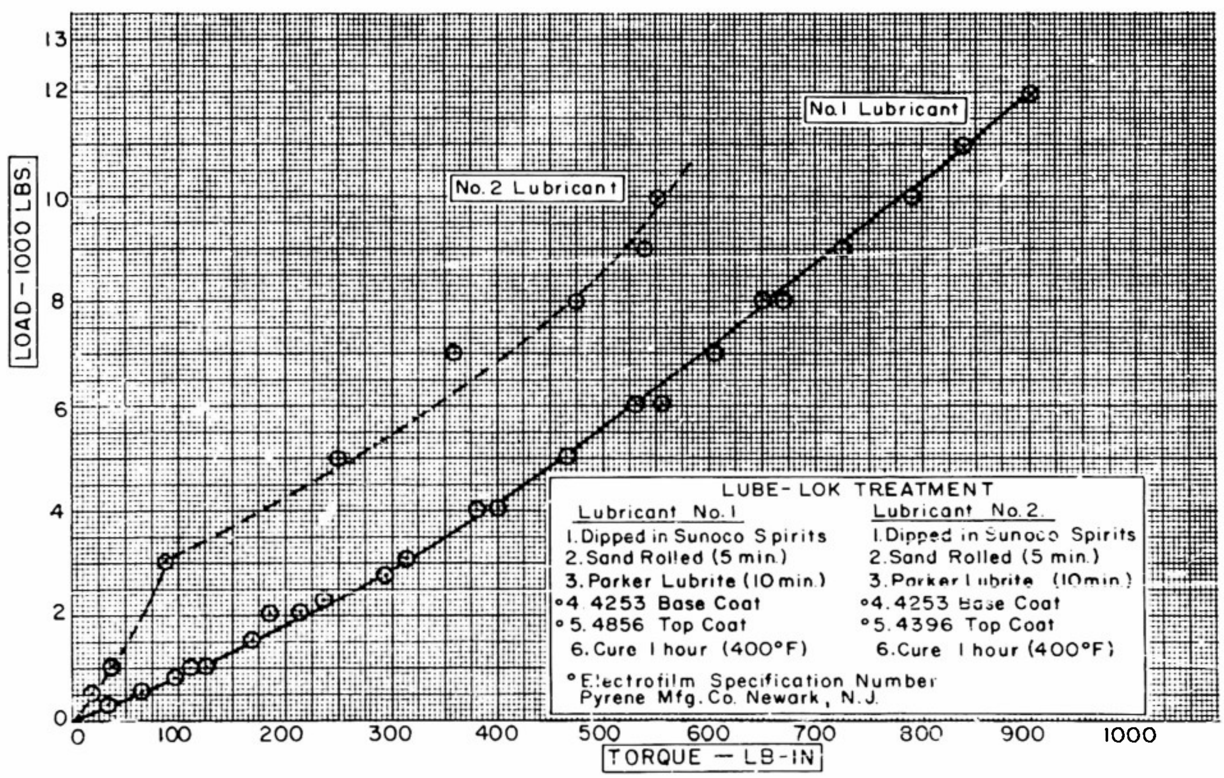


Fig. 8. Load Torque Behavior.
DRA215-218 Bearing System.

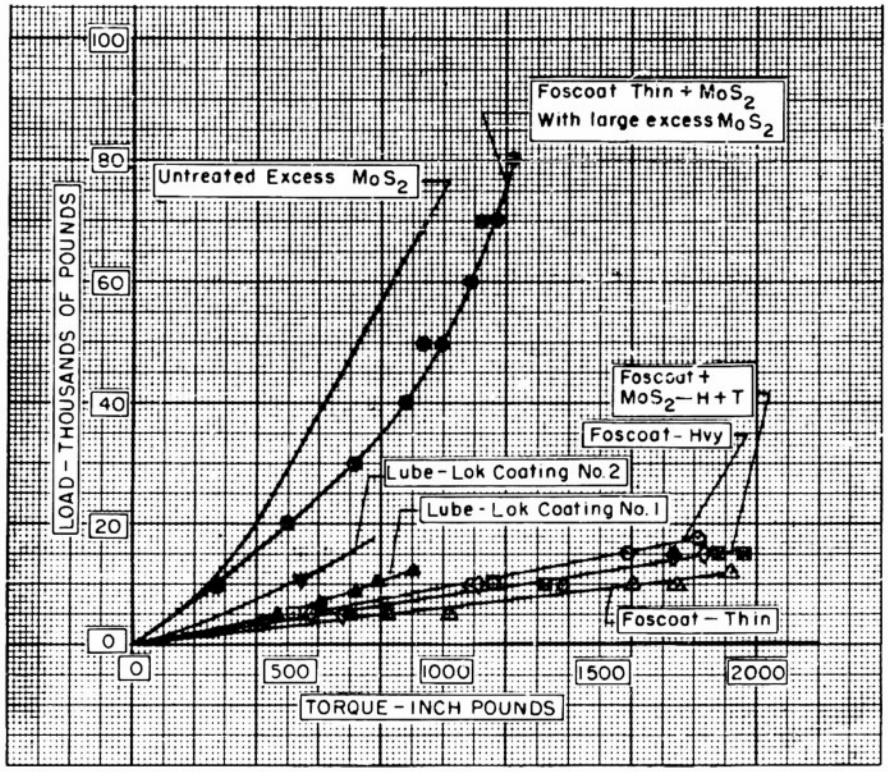


Fig. 9. Load Torque Behavior.
DRA215-218 Bearing System.

Dynamic Tests

To evaluate the No. 2 Lube-Lok coating under dynamic loading conditions, two double-body test projectiles with DRA 215-218 bearing systems treated with this lubricant were fired from a T19 rifle, through spin screens, into a recovery box. Table IX is a record of the firing data and illustrations of the projectiles used appear there.

The first round had a measured spin rate of 26 rps between spin screens 1 and 2, and a spin rate of 28.6 rps between spin screens 2 and 3 (calculated on the assumption that the velocity was the same as for projectile No. 2). The second round had a spin rate of 18.7 rps between spin screens 1 and 2, and a spin rate of 19.9 rps between spin screens 2 and 3. The results indicate the "non-rotating" section of each projectile was rotating at a rate equal to approximately 10% to 12% of the spin imparted to the projectile by the tube, and that there may have been an approximate 1% increase in spin rate between the first and second screen pairs, a distance of 12.45 ft. The latter observation is not believed to be sufficiently precise to be significant.

No muzzle velocity was obtained for the first round because of a malfunction in the chronograph. A reading was obtained which resulted in a calculated muzzle velocity of 2834 fps (instrumental), but this is obviously in error since earlier firing tests under similar conditions gave velocities of between 1650 and 1700 fps, which is in agreement with the 1655 fps muzzle velocity obtained for the second round. Both projectiles were recovered and an examination of the bearings disclosed severe wear of the Lube-Lok surface and some brinelling of the bearings.

Table IX
Range Data
To Investigate Spin Of Double Body Projectile

Date of Test 26 MARCH 1954
Location ERIE ORDNANCE DEPOT

Purpose of Test TO CHECK SPIN OF DOUBLE BODY PROJECTILE

PROJECTILE

Model DOUBLE BODY
Type ____
Weight 17.5 lb. (Nom.)
C.G. Location ____
Bourrelet Dia 4.182 $^{-.002}$
Retard. Factor ____
Special Features DRA 215-218 BEARING SYSTEM

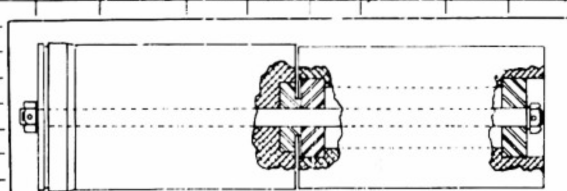
TEST GUN

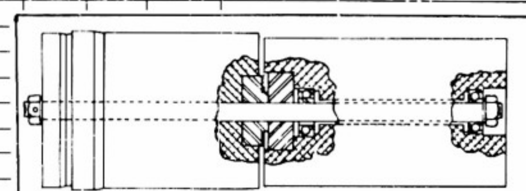
Model T19
Type 106mm Recoilless
Serial No. 6
Chamber (6) 2699-1-12931
Bushing(Vent) YA 804
Tube 7532-7-12162
Sighting Equip M17 Elbow
Mount:
Type Pendulum Ser. No. ____
Constant 2.58 lb sec/in.
Firing Mech. ____

MISCELLANEOUS DATA

Range Small Recovery Box
Propellant:
Type MP M10 Web .025 in Weight 7 lb-14 oz.
Lot No. PA-30259
Primer M57
Shell Case T63E1
Liner Prototype
Temperatures:
Magazine
Max. 73°F Min. 71°F Present 71°F
Loading Room 68°F Ambient 43°F

Round Number	Proj. Number	Proj. Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.				Observations
7004 1		17.58	7-14	9200 9700	②	②									2R	1	Unsealed Bearing ① Misfire
7005 2		17.52	7-14	9700 8100	1655	1683									2R	2	Sealed Bearing
3																3	
4		NOTES:														4	
5			1. Firing pin in backwards. Pin did not hit primer.													5	
6			2. Velocity time for this round was .01492 sec. This was an													6	
7			error since calculated velocity from this would be													7	
8			2834 ft/sec. Had it read .02492 sec. then velocity													8	
9			would have been 1698 ft/sec. (INST). There is a													9	
10			possibility that the blast may have triggered the													10	
11			chronograph.													11	
12			3. Spin screen wire spacing was from left to right													12	
13			1 in., 1/2 in., 1/4 in., respectively.													13	
14																	
15																	
16																	
17																	
18																	
19																	
20																	
21																	
22																	


USED WITH LUBRICANT No.1


USED WITH LUBRICANT No.2

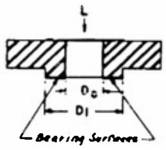
Muzzle — 100.85' — 1 — 6.19' — 2 — 18.76' — 3
Screen (Coil) Distances

Proof Director R. Deruyoe PROD DIR M. Manofsky

Coefficient Of Friction, Static and Dynamic

Coefficients of friction for DRA 215-218 bearings with each lubricant were calculated for each of the loads applied in the static tests of Table VIII. The results are shown in Table X and the bearing pressure-coefficient of friction relationship is shown in Fig. 10.

Table X
Coefficient Of Friction
DRA215-218 Bearing System Under Load



$$T = \frac{\mu L}{3} \frac{\left(D_I^3 - D_o^3\right)}{\left(D_I^2 - D_o^2\right)}$$

		Unit
T	= torque due to resistance of bearing surface	lb-in
μ	= coefficient of friction of bearing	
L	= load applied to bearing	lb
D_I	= outside diameter of bearing surface	in
D_o	= inside diameter of bearing surface	in

For Collar Step DRA-218

$$\mu = \frac{T}{L}\left(\frac{3}{1.16945}\right) = \left(\frac{T}{L}\right) 2.5653$$

L Load	L/A Bearing Pressure	T Friction Torque	T / L	μ Coefficient of Friction
Lubricant No 1				
1000	1709.1	125	.124	.3707
2000	3418.2	225	.1125	.2886
3000	5127.3	315	.105	.2694
4000	6836.4	390	.0975	.2501
5000	8545.5	465	.0930	.2386
6000	10254.7	530	.0883	.2265
7000	11963.8	595	.0850	.2181
8000	13672.9	665	.0831	.2132
9000	15382.0	725	.0806	.2068
10000	17091.0	785	.0785	.2014
11000	18800.2	840	.0764	.1959
12000	20509.3	900	.0750	.1924
Lubricant No 2				
500	855	18	.036	.0924
1000	1709.1	30	.030	.0769
3000	5127.3	87	.029	.0744
5000	8545.5	252	.051	.1308
7000	11963.8	360	.052	.1334
8000	13672.9	477	.059	.1514
9000	15382.0	540	.060	.1539
10000	17091.0	551.5	.055	.1411

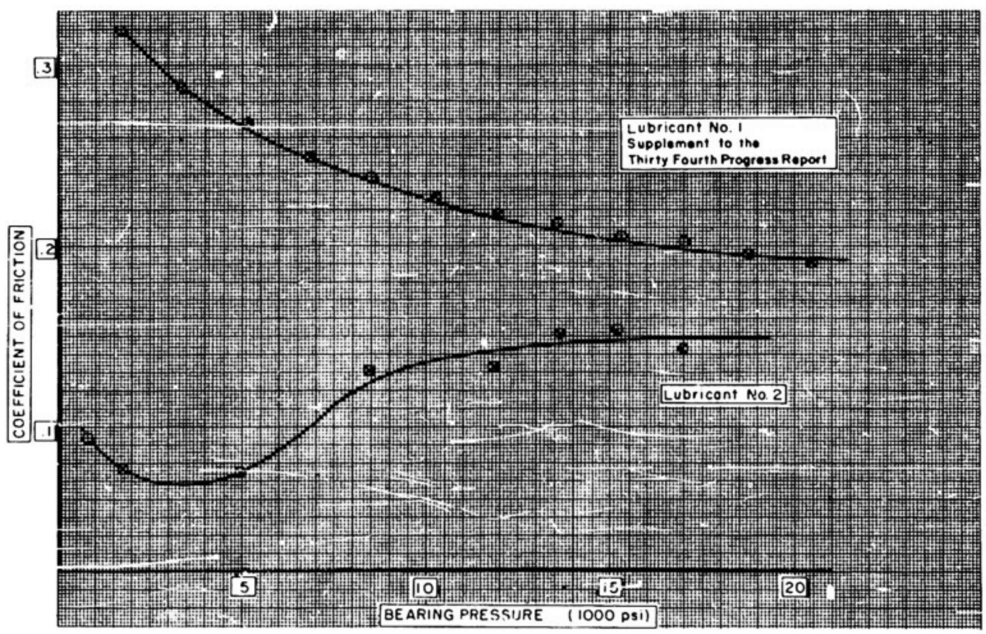


Fig. 10. Effect Of Bearing Pressure. On Coefficient Of Friction. DRA215-218 Bearing System.

As was stated earlier in this report, the primary purpose of this current test was to determine whether this new lubricant would be effective in lowering the coefficient of friction at low loads. It is relatively clear from the graphs (Figs. 8 and 10) that this has been accomplished; however, as the loading is progressively increased the new lubricant appears to undergo a change at some point between 2000 and 4000 lbs and additional points seem to parallel very closely those plotted for lubricant No. 1. It appears that the coefficient of friction for lubricant No. 2 is leveling off at a value of approximately 0.15 in comparison with 0.2 reported for lubricant No. 1.

Using the calculated pressure-time curve shown in Fig. 11, page 16, of the Supplement to the Thirteenth Progress Report, and the known physical constants of this system, average effective coefficients of friction for the dynamic test were calculated to be between .028 and .038 with the No. 2 lubricant. However, it should be pointed out that the double body projectile assemblies used in this test differed from those of the earlier test in that they incorporated a Fafnir angular contact bearing, number 7201 K, as a pilot bearing in place of the DRA 215 pilot bearing. It is believed that the 7201 K bearing minimizes side thrust and largely eliminates the torque which would result from this side thrust. Therefore, it is not certain whether the lower spin rates obtained in the dynamic tests with the No. 2 lubricant results from the lubricant alone or from the 7201 K bearing.

Dynamic Tests Of Compensating Liners

The problems involved in selecting a projectile for dynamic firing tests with spin compensating liners were discussed in the Forty-Fourth Progress Report. Initial tests were conducted using T119-E10 projectiles, equipped with rotating bands and fins modified to maintain a predetermined spin rate over the desired target range of 500 ft. However, measured spin for these projectiles indicated an approximate decrease of 50% over that spin imparted to the projectile by the tube. Data for this test are reported in the Forty-Fourth Progress Report. In that report a future program was outlined in which T138-E57 projectiles were to be modified to include a cylindrical section between the tee and body, thus providing the added clearance required for penetration. Projectiles with sleeves 1 in and 2 in long were prepared and have been tested for accuracy.

T138E57 Projectiles

Fifteen T138E57 projectile were used for this test. Five rounds were assembled with a 1 inch sleeve placed between the tee and body and a second group of five rounds were assembled with a 2 inch sleeve placed between the tee and body. The remaining five rounds were assembled as standard T138E57 projectiles (without sleeve) and were fired as control rounds (see Fig. 11 for assemblies). All were inert loaded and fired for accuracy at a 478 ft. target. Each projectile was equipped with a DRB 360 rotating band and fired through a T137-E3 rifle with a 1/80 twist tube so as to have a muzzle spin rate of 60 rps at 1700 fps muzzle velocity. Table XI is the firing record for this test. The target used was a plywood panel (4'x8'x1/2") located 478 ft from the muzzle of the gun. Fig. 12 shows the target and position of hit. Table XII is a summary of the results obtained from this test.

These data show that reasonable accuracy can be maintained over a 500 ft range with the T138E57 projectile using both the 1 inch and 2 inch sleeves. Since the spin rate of this projectile can also be controlled by the use of rotating bands and a tube with the proper twist, similar projectiles will be used as carriers for dynamic fluted cone tests.

Table XI
Range Data
Flight Test T138E57 Projectile With Sleeve

Date of Test 28 APRIL 1954
Location Erie Ordnance Depot

Purpose of Test FLIGHT TEST T138E57 PROJECTILE W/SLEEVE

PROJECTILE

Model T138X
Type TEE
Weight 17.9 lb. (Nom.)
C.G. Location Varies
Bourrelet Dia. 4.132 $^{-.002}$
Retard. Factor 2.45
Special Features TEE RINGS DRB1034 & DRB1035

TEST GUN

Model T137E3
Type 106 mm Recoilless
Serial No. 9
Chamber 22B-564-L-B
Bushing(Vent) 22C-155-K
Tube 1/80 22B-345-E
Sighting Equip T183 #27 (Bore Sight)
Mount:
Type T152E5 Ser. No. 1
Constant
Firing Mech. ONTOS

MISCELLANEOUS DATA

Range 500 Ft.
Propellant:
Type MPM10 Web .085 in Weight Varies
Lot No. PA-30259
Primer M57
Shell Case T62E1
Liner T59
Temperatures:
Magazine
Max. 73°F Min. 71°F Present 73°F
Loading Room 91°F Ambient 52°F

Round Number	Proj. Number	Proj Weight (lb.)	Propell. Weight (lb.-oz.)	Chamber Pressure (psi) (Cu) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim. (mils)	Elevation (mils) zero	Elevation (mils) super	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.				Observations
7115-1	TR-1	16.96	7-14	5300 / 9700	1679	1697				-7	-8	-.408	-.466	4 1/8	4 1/2	1	(INDICATOR LIT AFTER FIRING) (BLAST INDICATOR NOT LIT WHEN CLOSED)
7116-2	TR-2	16.94	7-14	9400 / 9900	1676	1694				-6 1/2	-5	-.379	-.291	4 1/8	4 1/4	2	" " NOT LIT WHEN CLOSED
7117-3	TR-3	16.96	7-14	9900 / 10700	1682	1700				-12 1/2	0	-.729	0	4 1/8	4 1/8	3	" " " " " "
7118-4	TR-4	16.96	7-14	8500 / 8700	1691	1709				0	+1	0	+.058	4 1/8	4 1/4	4	" " " " " "
7119-5	TR-5	16.98	7-14	9800 / 10000	1688	1706				+4 1/2	-1/2	+.262	-.029	4 1/8	4 3/8	5	
7120-6	TR-6	17.57	8-0	10600 / 10400	1659	1677				+14	-8	+.817	-.466	—	4 1/4	6	NO LIGHT CUP ONLY
7121-7	TR-7	17.54	8-0	10700 / 10400	1651	1669				+12	-8 1/2	+.700	-.496	4 1/8	—	7	LIGHT DOUBLE PUSH
7122-8	TR-8	17.51	8-0	10800 / 10700	1656	1674				-1/2	-5	-.029	-.291	4 1/8	4 1/4	8	" " "
7123-9	TR-9	17.56	8-0	10300 / 10800	1676	1694				0	+13	0	+.759	4 1/8	4 1/4	9	NO LIGHT LIT WHEN BREECH WAS OPENED CUP ONLY SET BACK
7124-10	TR-10	17.56	8-0	[illegible] / 10600	1651	1669				+9	+7	+.525	+.407	4 1/8	4 1/4	10	LIGHT LIT
7125-11	TR-11	18.70	8-0	10300 / 10100	1622	1640				+2 1/2	+20 1/2	+.196	+1.46	4 1/8	4 3/4	11	" "
7126-12	TR-12	18.76	8-0	10700 / 10500	1611	1629				+3 1/2	-18 1/2	+.204	-1.08	4 1/8	4 1/8	12	" "
7127-13	TR-13	18.74	8-2	10700 / 10900	1637	1655				+10	+3 1/2	+.583	+.204	4 1/8	4 1/8	13	" "
7128-14	TR-14	18.78	8-2	10700 / 10600	1642	1660				+5	+5 1/2	+.291	+.32[illegible]	4 1/8	4 3/4	14	" "
7129-15	TR-15	18.76	8-2	10500 / 10300	1625	1643				-10	+10	-.583	+.583	4 1/8	4 3/4	15	" "
16																16	
17																17	
18																18	
19																19	
20																20	
21																21	
22																22	

Muzzle ⊢— 53.36' —+— 40.99' —⊣ 2
Screen (Coil) Distances

Proof Director E. HUFFMAN   PROG. DIR. M. MANOFSKY

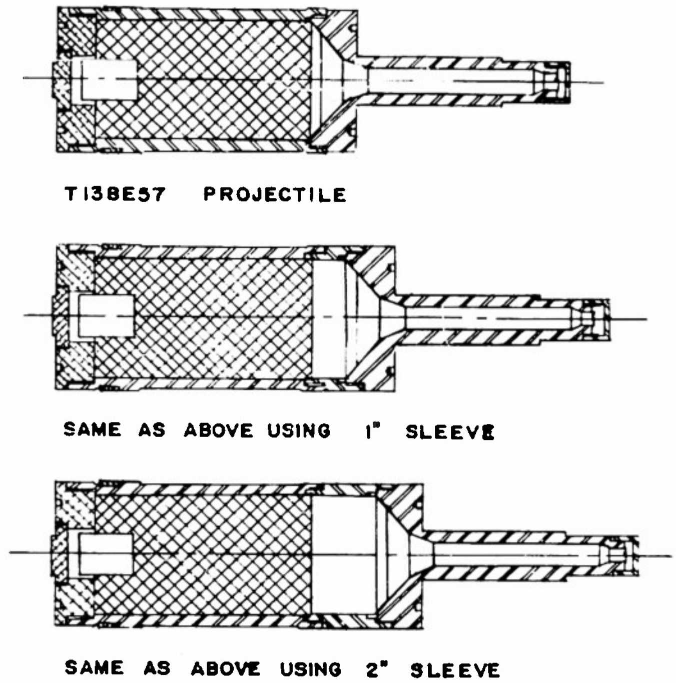


Fig. 11. T138E57 Projectile Assemblies.
With and Without Sleeves.

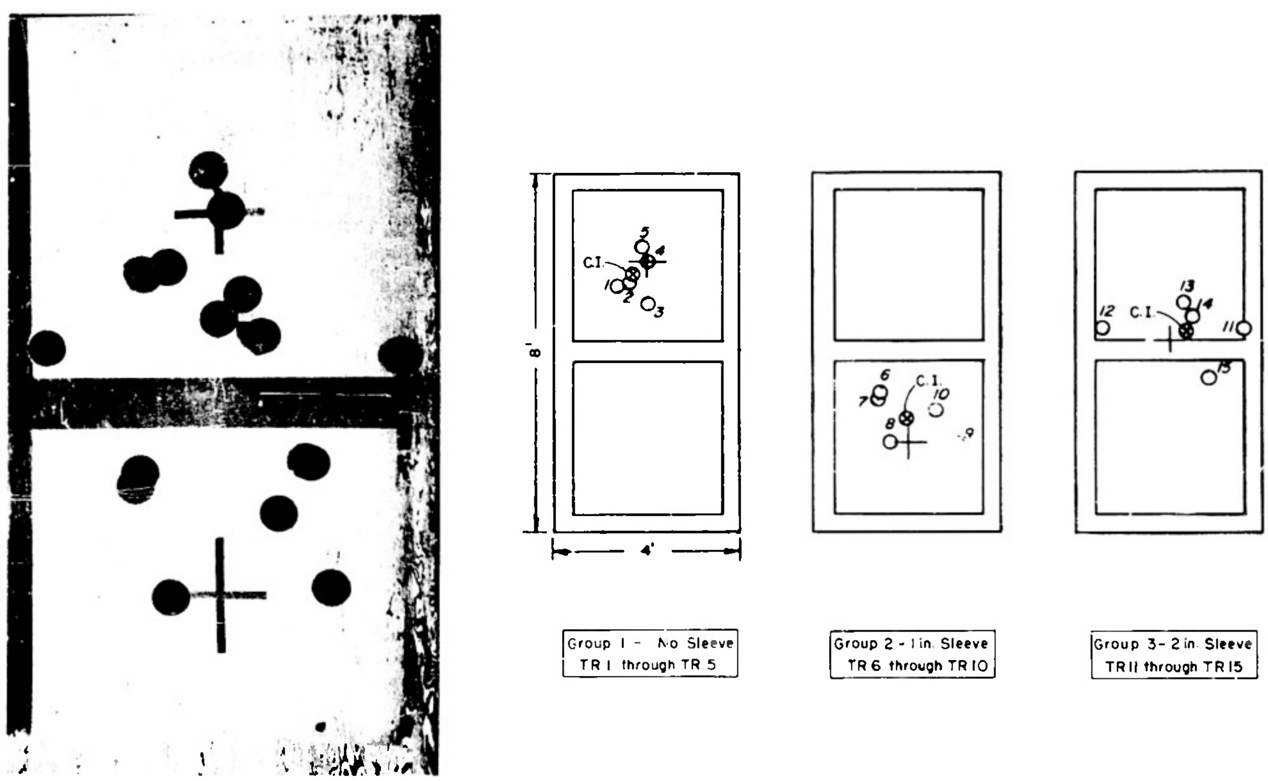


Fig. 12. Target Showing Position Of Hits.
T138E57 Type Projectiles (With and Without Sleeves).

Table XII
Summary Of Flight Test Results
T138E57 Type Projectiles

Round Number	Aiming Point	Center of Impact (mil) Vertical	Center of Impact (mil) Horizontal	Probable Error (mil) Vertical	Probable Error (mil) Horizontal
GROUP No. 1 NO SLEEVE					
TR1-5	Center Of Upper Half Of Target	-.250	-.232	±.257	±.250
GROUP No. 2 1-INCH SLEEVE					
TR6-10	Center Of Lower Half Of Target	+.406	-.017	±.260	±.564
GROUP NO. 3 2-INCH SLEEVE					
TR11-15	Center of Band Of Tape	+.128	+.244	±.289	±.825

	Group 1	Group 2	Group 3
Average Projectile Weight (lb)	16.46	17.55	18.75
C.G. Location From Base (in)	4.95	5.36	5.83
Axial Moment Of Inertia (lb-in^2)	43.0	44.26	46.59
Transverse Moment of Inertia (lb-in^2)	204.0	231.4	271.0

Future Program

1. Serrated Liners

a. Effect of Index Angle
Two lots of cones of the DRD78 type, described in the Supplement to the Thirty-Fourth Progress Report, having index angles of 5° and 20°, and having minimum wall thickness of .100 in. have been tested and will be reported in the June report.

b. DRD433 item 2 and item 3 cones (Index angle 6° and 2°, respectively) are being manufactured. These cones have 50 "matching" flutes .034 in. deep at the base datum and a wall thickness of .100 in.

c. DRD429 item 2. These cones have 16 "matching" flutes, .034 in. deep at the base datum and a wall thickness of .100 in. Index angle is 6°. Flute orientation is the reverse of DRD78.

d. DRD434 item 2. Same as (c) except flute depth is .060 in.

e. Scaling Studies
DRD267 (3.5 in. base x .100 in. wall); DRB704 (3.0 in. base x .087 in. wall); DRB703 (2.5 in. base x .071 in. wall). These cones to have 60 flutes machined in outside to a depth of .010 in., .0085 in., and .0069 in. at base datum for each of three sizes.

f. Threaded Cones
DRB998, threaded inside, 60°V threads 28/in., .0097 in. deep, .0357 in. pitch.

DRB999, triple threaded inside, 60°V threads, 84/in., .0097 in. deep, .0119 in. pitch, .0357 in. lead.

DRB1000, threaded outside, 60°V threads, 28/in., .0375 in. pitch, 0097 in. deep.

DRB1001, triple threaded outside, 60°V threads, 84/in. .0357 in. lead, .0119 in. pitch, .0097 in. deep.

The above cones are being tested.

2. Double Body Projectile Study.

a. Six projectiles are to be fired to complete the study on the determination of minimum wall thickness required in non-rotated body. The projectiles have wall thicknesses as follows:

(1) 2 rounds with .180 in. wall (alum) in rear body.

(2) 2 rounds with .120 in. wall (alum) in rear body.

(3) 2 rounds with .060 in. wall (alum) in rear body.

Assemblies are being inspected.

b. Determination of Strength of Tee Or Boom. Tees of five different designs and strength, using both aluminum and steel, are to be tested. Manufacture is completed and tests are scheduled for June.

Aluminum Cones, Effect Of Spin

The present experiment was undertaken to determine the effect of spin and cone wall thickness on the performance of machined 2S-F aluminum cones at standoffs of 7.5 inches and optimum standoffs of 42 inches for a .100-inch wall and 48 inches for a .200-inch wall cone. The effect of standoff and cone wall thickness and a comparison of 2S-F and Alloy No. 43 aluminum cones were presented in the Thirty-Eighth Progress Report.

In this experiment the cones were made to DRB 398 HW3 specifications and assembled in DRC 376 test assemblies with No. 2 Nose Rings (Figs. 35 and 36 of the Thirty-Seventh Progress Report). The cones were machined from 2S-F bar stock to wall thicknesses of .100 in. (Item 1) and .200 in. (Item 5). Copper DRB 398 HW3 Item 1 cones were used as controls for the study.

The cone inspection data are recorded in Tables XIII, XIV and XVI. The penetration data are shown in Tables XVII, XVIII and XX and in Fig. 13.

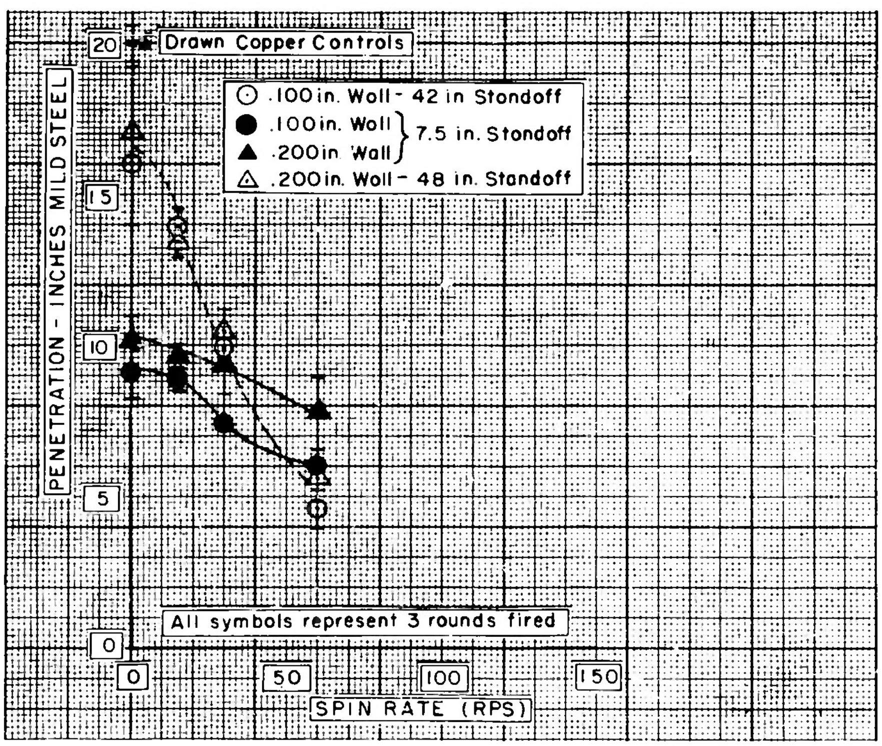


Fig. 13. Penetration Versus Rotation.
Effect Of Spin On Aluminum Cone Performance.

The following observations are pertinent:

1. The .200-inch wall cone performs better at the 7.5 in. standoff than the .100-inch wall cone at all the spin rates up to 60 rps.

2. The performances of both the .100 and .200-inch wall cones at their optimum standoffs of 42 and 48 inches, respectively, are quite similar and a single curve can be drawn representing both sets of test data.

3. The level of penetration at the longer standoff is, in each case, higher than at the 7.5 inch standoff for spin rates below 35 rps. At higher spin rates the performance of the rounds fired at longer standoffs falls off more rapidly than at the 7.5-inch standoff and at 60 rps their penetration is lower.

DRB-23-974-2 Heavy Apex Cones

This experiment was performed to determine the penetration efficiency of a heavy apex, copper cone. The cones were made to DRB-23-974-2 specifications as shown in Fig. 14 and assembled into DRC 376 test assemblies with No. 2 Nose Rings. The cones were machined from copper bar stock to a wall thickness of .100 in. in the lower region which increased to .200 in. at the apex. Copper DRB 398 HW3 item 1 cones were used as controls for this study.

The cone inspection data are shown in Tables XV and XVI and the penetration data are recorded in Tables XIX and XX. A comparison is made with the controls in the following table.

Cone Drawing No.	Average Penetration (inches M.S)	Max.Spread (in.)	Std. Deviation (in.)
DRB-23-974-2	22.11	3.57	± 1.40
DRB 398 HW3 Item 1	20.02	1.63	± .60

The average penetration of the DRB-23-974-2 cones is considerably higher than the controls at the 7.5-inch standoff considered. It is believed that the design of the apex aids the collapse mechanism of the cone in a manner similar to that of a cone with a flash back tube.

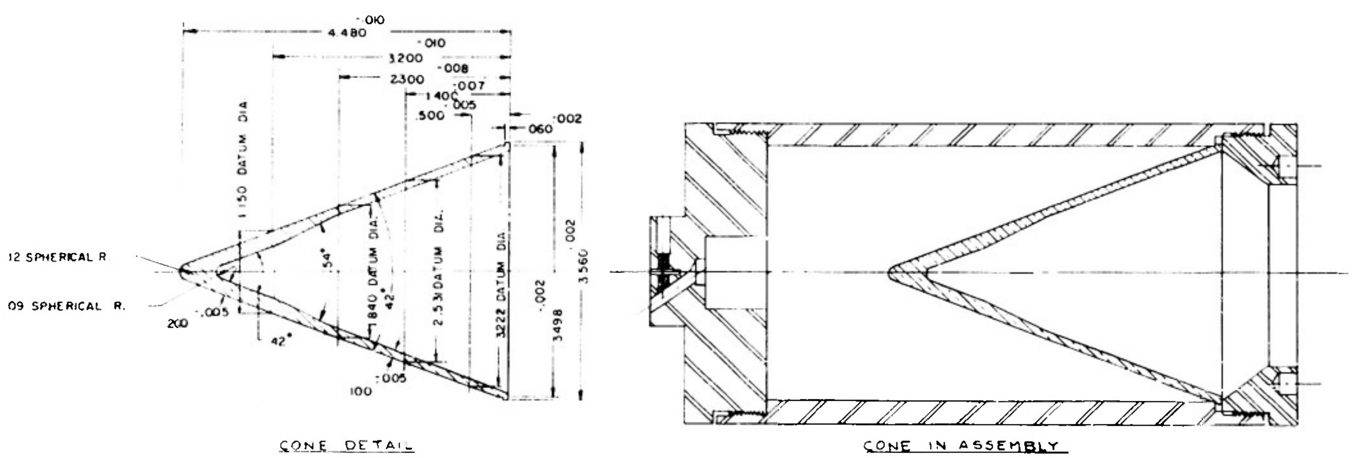


Fig. 14. Heavy Apex Copper Cone.
Firestone Drawing DRB-23-974-2.

Table XIII
Inspection Data
Aluminum DRB398 HW3 Item 1 Cones

Cone Number	Wall Thickness (inches)			Max Wall Thickness Variation (inch)		Max Wall Waviness (inch)		Concentricity - T.I.R.[1,2]		
	Max	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB 398 HW3 Item 1	.105	.100		.002	.006	.006	.006	.003	.003	Nominal .015
A171	.103	.101	.1019	.001	.002	< .001	< .001	.002	.002	.007
A172	.102	.090	.1001	.001	.004	< .001	< .001	.002	.003	< .001
A173	.103	.101	.1019	.001	.002	< .001	< .001	.001	.004	.005
A174	.102	.101	.1015	< .001	.001	< .001	< .001	.001	.001	.003
A175	.103	.102	.1025	< .001	.002	< .001	< .001	.001	.001	.008
A176	.103	.101	.1020	< .001	.002	< .001	< .001	.003	.002	.003
A177	.102	.100	.1014	.001	.002	< .001	< .001	.002	.003	.006
A178	.103	.102	.1024	.001	.001	< .001	< .001	.001	.001	.004
A179	.103	.101	.1021	.001	.002	< .001	< .001	.002	.001	.008
A180	.104	.103	.1035	< .001	.001	< .001	< .001	.002	.001	.004
A181	.103	.100	.1015	< .001	.003	< .001	< .001	.002	.002	.002
A182	.102	.100	.1012	.001	.002	< .001	< .001	.002	.001	.004
A183	.102	.099	.1004	.003	.002	< .001	< .001	.002	.001	.010
A184	.103	.100	.1019	.001	.003	< .001	< .001	.002	.001	.004
A185	.103	.102	.1025	< .001	.001	< .001	< .001	.002	.005	.006
A186	.104	.102	.1030	< .001	.002	< .001	< .001	.004	.003	.008
A187	.104	.101	.1027	.001	.003	< .001	< .001	.001	.001	.012
A188	.104	.101	.1022	.001	.003	< .001	< .001	.003	.001	.009
A189	.104	.100	.1020	.001	.003	< .001	< .001	.003	.003	.006
A190	.104	.103	.1035	< .001	.001	< .001	< .001	.001	.002	.006
A191	.103	.102	.1025	< .001	.001	< .001	< .001	.003	.003	.003
A192	.104	.102	.1032	.001	.002	< .001	< .001	.003	.003	.005
A193	.103	.102	.1025	< .001	.001	< .001	< .001	.003	.005	.003
A194	.103	.102	.1025	< .001	.001	< .001	< .001	.002	.003	.004
* A195	.103	.102	.1025	< .001	.001	< .001	< .001	.002	.002	---
Avg.	.1031	.1011	.1021	.0006	.0019	< .001	< .001	.0021	.0022	.0054
Std. Dev.	±.0007	±.0012	±.0008	±.0007	±.0008	----	----	±.0008	±.0012	±.0027

Notes:

1. Base datum is .484 inch above base; apex datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the tunout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
3. * Held for Display.

Table XIV
Inspection Data
Aluminum DRB398 HW3 Item 5 Cones

Cone Number	Wall Thickness (inches)			Max. Wall Thickness Variation (in)		Max. Wall Waviness (inch)		Concentricity - T.I.R.[1,2]		
	Max	Min.	Avg.	Transv.	Longitud.	O. D.	I. D.	Base Datum	Apex Datum	Cone Tip in Assembly
Specification DRB 398 HW3 Item 5	.205	.200		.002	.006	.006	.006	.003	.003	Nominal .015
A196	.203	.201	.2020	< .001	.002	< .001	< .001	.003	.003	.004
A197	.202	.200	.2015	.002	.001	< .001	< .001	.002	.002	.007
A198	.203	.201	.2022	.001	.002	< .001	< .001	.003	.007	.007
A199	.203	.199	.2010	.002	.003	< .001	< .001	.002	.003	.011
A200	.205	.204	.2045	.002	.003	< .001	< .001	.003	.004	.006
A201	.204	.204	.2040	< .001	< .001	< .001	< .001	.002	.002	.008
A202	.203	.202	.2025	< .001	.001	< .001	< .001	.005	.005	.005
A203	.203	.202	.2025	< .001	.001	< .001	< .001	.003	.003	.007
A204	.206	.204	.2048	.001	.002	< .001	< .001	.002	.005	.009
A205	.203	.203	.2030	< .001	< .001	< .001	< .001	.002	.004	.005
A206	.204	.203	.2035	< .001	.001	< .001	< .001	.001	.004	.009
A207	.203	.203	.2030	< .001	< .001	< .001	< .001	.002	.002	.003
A208	.201	.200	.2005	< .001	.001	< .001	< .001	.004	.006	.003
A209	.202	.200	.2010	< .001	.002	< .001	< .001	.004	.005	.006
A210	.202	.201	.2015	.001	.001	< .001	< .001	.003	.007	.006
A211	.203	.202	.2027	.001	.001	< .001	< .001	.002	.004	.003
A212	.203	.201	.2017	.001	.002	< .001	< .001	.002	.006	.006
A213	.202	.201	.2017	.001	.001	< .001	< .001	.002	.006	.006
A214	.202	.201	.2015	< .001	.001	< .001	< .001	.002	.004	.002
A215	.200	.200	.2000	< .001	< .001	< .001	< .001	.002	.003	.002
A216	.200	.200	.2000	< .001	< .001	< .001	< .001	.005	.002	.009
A217	.203	.202	.2025	< .001	.001	< .001	< .001	.001	.003	.006
A218	.202	.201	.2015	< .001	.001	< .001	< .001	.003	.003	.009
A219	.202	.201	.2019	.001	.001	< .001	< .001	.004	.003	.007
* A220	.203	.202	.2025	< .001	.001	< .001	< .001	.003	.002	----
Avg.	.2027	.2015	.2021	.0005	.0012	< .001	< .001	.0027	.0039	.0061
Std. Dev.	±.0013	±.0014	±.0012	±.0007	±.0008	----	----	±.0011	±.0016	±.0024

Notes:

1. Base datum is .484 inch above base; apex datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
3. * Held for display.

Table XV
Inspection Data
DRB-23-974-2 Heavy Apex Cone

Cone Number	Wall Thickness - .500" Datum			Wall Thickness 2.300" Datum			Wall Thickness 3.200" Datum			Transverse Max. Wall Thickness Variation (in.)			Max Wall Waviness O. D. (in.)	Concentricity - T. I. R.[1,2]		
	Max	Min	Avg	Max.	Min.	Avg.	Max	Min.	Avg	.500" Datum	2.300" Datum	3.200" Datum		.500" Datum	3.200" Datum	Cone Tip in Assembly
Specification DRB-23-974-1	.100	.095		.100	.095		.200	.195		.001	.001	.001	.003	.003	.003	Nominal .015
D21	.101	.100	.1005	.101	.100	.1002	.205	.204	.2042	.001	.001	.001	.002	.002	.002	.005
D22	.102	.100	.1010	.101	.100	.1008	.204	.203	.2032	.002	.001	.001	.002	.003	.003	.002
D23	.099	.097	.0980	.099	.098	.0982	.194	.194	.1940	.002	.001	<.001	.002	.003	.003	.004
D24	.102	.100	.1008	.102	.100	.1008	.195	.195	.1950	.002	.002	<.001	.002	.002	.001	.010
D25	.102	.100	.1010	.101	.100	.1002	.193	.193	.1930	.002	.001	<.001	.002	.002	.001	.005
* D26	.100	.099	.0998	.101	.100	.1008	.203	.203	.2030	.001	.001	<.001	.001	.003	.003	----
Avg.	.1010	.0993	.1002	.1008	.0997	.1002	.1990	.1987	.1987	.0017	.0012	.0005	.0018	.0025	.0020	.0052
Std. Dev.	±.0013	±.0013	±.0012	±.0010	±.0009	±.0010	±.0056	±.0052	±.0052	±.0006	±.0004	±.0006	±.0004	±.0006	±.0009	±.0030

Notes:
1. The datum locations were .500, 2.300, and 3.200 inches above the base of the cone.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
3. *Held for display.

Table XVI
Inspection Data
DRB398 HW3 Item 1 Copper Controls

Cone Number	Wall Thickness (inch)			Max. Wall Thickness Variation (in.)		Max. Wall Waviness (inch)		Concentricity - T.I.R.[1,2]		
	Max.	Min.	Avg.	Transv.	Longitud.	O.D.	I.D.	Base Datum	Apex Datum	Cone Tip in Ass'y.
Specification DRB 398 HW3 Item 1	.105	.100		.002	.006	.006	.006	.003	.003	Nominal .015
G16	.105	.100	.1027	.002	.004	.002	.001	.004	.004	.011
G17	.103	.102	.1025	< .001	.001	.003	.001	.002	.002	.004
G18	.104	.101	.1031	.002	.003	.002	.001	.004	.004	.003
G19	.106	.103	.1042	.003	.001	.003	.001	.006	.007	.010
G20	.105	.100	.1026	.001	.005	.003	.001	.006	.003	.007
Avg.	.1046	.1012	.1030	.0016	.0028	.0026	.0010	.0044	.0040	.0070
Std. Dev.	±.0012	±.0013	±.0007	±.0012	±.0018	±.0007	-----	±.0017	±.0019	±.0035

Notes:
1. Base datum is .484 inch above base; apex datum is 3.202 inches above base.
2. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.

Table XVII
Penetration Data
DRB398 HW3 Item 1, 2S-F Aluminum Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)		Max. Spread (in.)	Std. Deviation (in.)
A171	2.52	0	7.5		8.44		
A172	2.52	0	7.5		9.94		
A173	2.50	0	7.5		8.88		
				Avg.	9.09	1.50	± 0.77
A174	2.52	15	7.5		8.81		
A175	2.52	15	7.5		9.31		
A176	2.50	15	7.5		8.62		
				Avg.	8.91	0.69	± 0.36
A177	2.52	30	7.5		7.44		
A178	2.50	30	7.5		7.19		
A179	2.52	30	7.5		7.56		
				Avg.	7.40	0.37	± 0.19
A180	2.52	60	7.5		6.12		
A181	2.52	60	7.5		6.44		
A182	2.52	60	7.5		5.44		
				Avg.	6.00	1.00	± 0.51
A183	2.52	0	42.0		14.19		
A184	2.52	0	42.0		18.06		
A185	2.52	0	42.0		15.75		
				Avg.	16.00	3.87	± 1.95
A186	2.52	15	42.0		14.19		
A187	2.52	15	42.0		14.38		
A188	2.52	15	42.0		13.19		
				Avg.	13.92	1.19	± 0.64
A189	2.52	30	42.0		11.38		
A190	2.52	30	42.0		9.50		
A191	2.52	30	42.0		8.88		
				Avg.	9.92	2.50	± 1.30
A192	2.52	60	42.0		4.81		
A193	2.50	60	42.0		5.19		
A194	2.52	60	42.0		3.81		
				Avg.	4.60	1.38	± 0.71

Notes:
1. DRB 398 HW3 Item 1 (.100 wall) machined 2SF aluminum cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Table XVIII
Penetration Data
DRB398 HW3 Item 5, 2S-F Aluminum Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (inches)	Penetration (inches M.S.)		Max. Spread (in.)	Standard Deviation (in.)
A196	2.52	0	7.5		10.94		
A197	2.50	0	7.5		10.38		
A198	2.52	0	7.5		9.38		
				Avg.	10.23	1.56	± .79
A199	2.52	15	7.5		9.31		
A200	2.52	15	7.5		9.94		
A201	2.52	15	7.5		9.94		
				Avg.	9.73	0.63	± .36
A202	2.52	30	7.5		9.00		
A203	2.52	30	7.5		10.81		
A204	2.50	30	7.5		8.75		
				Avg.	9.52	2.06	± 1.12
A205	2.52	60	7.5		7.25		
A206	2.50	60	7.5		9.00		
A207	2.52	60	7.5		6.69		
				Avg.	7.65	2.31	± 1.20
A208	2.52	0	48		19.69		
A209	2.50	0	48		15.50		
A210	2.50	0	48		16.19		
				Avg.	17.13	4.19	± 2.25
A211	2.52	15	48		13.25		
A212	2.52	15	48		12.94		
A213	2.50	15	48		13.94		
				Avg.	13.38	1.00	± 0.51
A214	2.52	30	48		10.69		
A215	2.52	30	48		10.94		
A216	2.50	30	48		9.81		
				Avg.	10.48	1.13	± 0.59
A217	2.52	60	48		6.06		
A218	2.54	60	48		5.56		
A219	2.54	60	48		5.19		
				Avg.	5.60	0.87	± 0.44

Notes:

1. DRB 398 HW3 Item 5 (.200 wall), machined 2SF aluminum cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Table XIX
Penetration Data
DRB-23-974-2 Copper Cones

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Deviation (in.)
D21	2.54	0	7.5	22.44		
D22	2.54	0	7.5	20.12		
D23	2.50	0	7.5	22.94		
D24	2.54	0	7.5	23.69		
D25	2.52	0	7.5	21.38		
				Avg. 22.11	3.57	± 1.40

Notes:
1. DRB-23-974-2 machined, copper cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Table XX
Penetration Data
DRB398 HW3 Item 1, Copper Cone Controls

Serial No.	Comp. B (lbs.)	Rotation (rps)	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (In.)	Std. Deviation (in.)
G16	2.52	0	7.5	20.06		
G17	2.52	0	7.5	19.88		
G18	2.52	0	7.5	19.12		
G19	2.54	0	7.5	20.75		
G20	2.52	0	7.5	20.31		
				Avg. 20.02	1.63	± .60

Notes:
1. DRB 398 HW3 Item 1, Drawn, copper cones were assembled into DRC 376 penetration assemblies using the No. 2 nose ring.
2. All rounds were loaded at Ravenna Arsenal, BAT Lot No. 54 using Holston Comp. B Lot 4-1197.
3. All rounds were fired at the Erie Ordnance Depot.

Future Program

1. Composite Cone Study

A series of bimetal cones with aluminum half-shell inserts (.020 in. thick) and copper outer shells (DRB 398 HW3 item 1) have been assembled to evaluate penetration performance at standoffs of 2, 4 and 6 inches and at varying rotational rates.

2. Evaluation Of Cones Made By Electroforming

A series of DRB-268-5 copper cones, made by an electroforming method, have been manufactured for comparison with machined cones of like design. The electroformed cones and controls have been manufactured.

3. Penetration Into Mild Steel Versus Homogeneous Armor

A series of penetration test rounds composed of DRB 398 HW3 item 1 cones in DRC 376 test bodies have been loaded and will be tested for penetration into homogeneous armor and mild steel at various spin rates.

4. Evaluation Of Cones Made By Zinc Die Casting

A series of DRB 398 HW3 cones have been made by die casting zinc alloy Zamak 3. Standoff and spin tests are planned.

5. Evaluation Of The DRB 398 HW3 Item 1 Copper Drawn Cone In Various Stages Of Manufacture.

A series of cones having varying geometric configurations have been obtained. These cones represent the various steps in the deep drawing of the DRB 398 HW3 Item 1 Copper Cone. Six of the eight drawing stages are included. Standoff and spin tests are planned.

6. Evaluation Of Optimum Wall Thickness For Cones With Various Apex Angles.

This study is being conducted using a 3.0 in. charge. The length of the spit-back tube (.625 in. dia.) will be varied to give the cone an overall height of 5.00 in.

a. Cone drawing number DRB 834-1, apex angle 30°, wall thickness .050 in., .070 in., .086 in., and .110 in.

b. Cone drawing number DRB 16-976, apex angle 45°, wall thickness .050 in., .110 in. and .150 in.

c. Cone drawing number DRB 16-972, apex angle 60° wall thickness .070 in., .110 in. and .150 in.

These cones are being manufactured.

7. Composite Loading: Comp B. And Inert Filler.

A series of penetration test rounds composed of DRB 398 HW3 Item 1 cones in DRC 376 test bodies have been assembled. The rounds will be loaded with four variations in filler. Groups will be loaded to levels of .5 in., 1.0 in. and 1.5 inches of wax above the cone base, the remainder of the charge being Comp. B. Control rounds will contain Comp. B. only.

Potted Lucky Elements

Efforts to increase the reliability of functioning of T119E11 shell upon ground impact have continued. The great sensitivity of "potted lucky" nose elements (Fig. 15) first revealed by the test reported in the Forty-Second Progress Report, has since been confirmed by much more extensive tests conducted at Aberdeen Proving Ground by Messrs. Wills and Farrell of the Recoilless Rifle Section. Table XXI shows the evaluation program as initially planned. The major portion has been completed, but, because of the extreme sensitivity observed with this type of nose element, phases 5 and 6 were subsequently cancelled. The rounds were

Table XXI
Original Evaluation Program
Sensitivity of Potted Lucky Nose Element

Phase	No. Shell	Range	Target
1	10	400 ft.	Homogeneous Armor Plate at 65° obliquity
2	15	400 ft.	Pine Boards Determine Minimum Thickness for functioning.
3	10	300 ft.	Soft Earth (Graze Functioning)
4	10	1000 ft.	Soft Earth (Graze Functioning)
5	10	1000 yds.	Soft Earth (Ground Impact Functioning)
6	5	2000 yds.	" " " " "
7	10	4000 yds.	" " " " "
8	5	4000 yds.	Water (Water impact functioning)

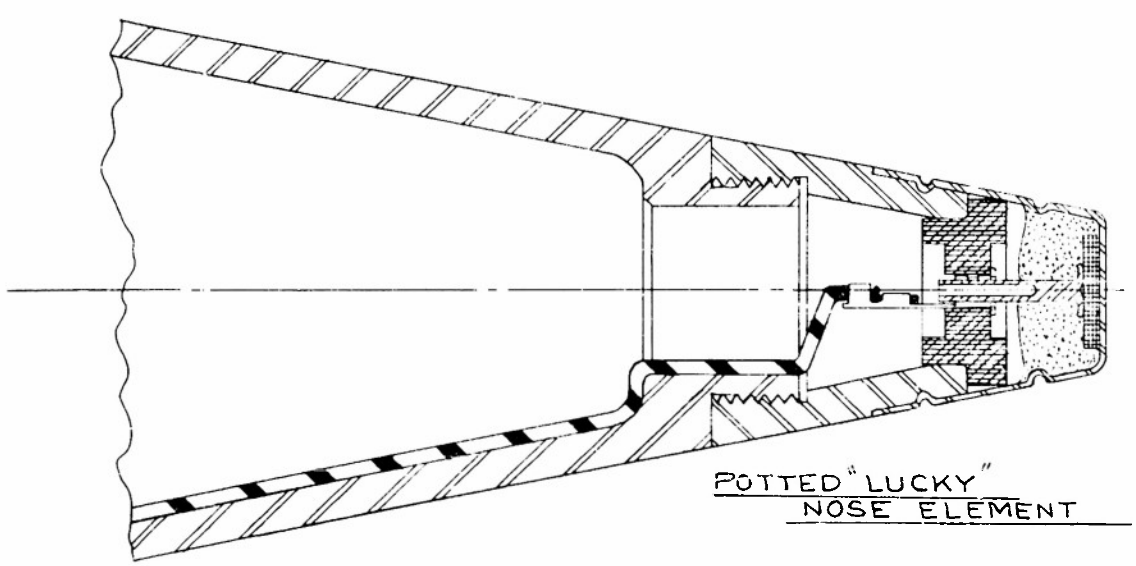


Fig. 15. Potted Lucky In Nose Cap Assembly.

loaded at Picatinny Arsenal, Lot No. PA-E-14899. The data for this program may be summarized as follows:

Phase 1

10 rounds at 400 ft against homogeneous armor plate target consisting of one 6-inch and two 1.5-inch plates at 65.5-degree obliquity.

All ten rounds functioned high order. In addition, ten rounds of Lot PA-E12356 with DRB683 (Fig. 5 of Forty-Fifth Progress Report) nose assemblies were fired as control rounds in this test and these also gave high order functions on the plate. No depth of penetration data are available but a comparison of the average penetration for the two groups will be reported at a later date.

Phase 2

14 rounds at 400 ft against pine boards (1 in), chip board (1/4 in) and kraft paper (.0045 in) to determine sensitivity.

The results are:

Serial No.	Target	Functioning
17908	1-inch pine	High Order
18047	"	" "
17996	"	" "
17943	"	" "
17938	"	" "
17981	"	" "
17883	1/4 inch chip board	" "
17959	Kraft paper	High Order
18046	" "	" "
18006	" "	FTF - FDR *
17910		High Order
17843		FTF-FDR
18053		FTF-FDR
--		High Order

* Failed To Function; Functioned Down Range

Phases 3 and 4

20 rounds at various ranges into a cultivated field. The field had been plowed, cultivated, drilled and seeded. Grass was about 4 to 6 in. high. Line of fire was parallel to the rows.

Nineteen of the twenty rounds functioned High Order as tabulated below:

Round No.	Range	Type Functioning
1 and 6	250 ft.	Both High Order
3	275 ft.	High Order
2,4,5,7,8,9	300 ft.	All High Order
10	300-325 ft.	FTF

Round 10 did not function although fin marks and body graze marks were evident from 300-325 ft.

18035	525 ft.	High Order
17895	625 ft.	High Order
17957	700 ft.	" "
17937	700 ft.	" "
17920	700 ft.	" "
17927	700 ft.	" "
17960	750 ft.	" "
17865	850 ft.	" "
17891	1000 ft.	" "
18008	1040 ft.	" "

Phase 7

10 rounds at 4000 yards into soft earth (swampy soil).

All 10 rounds functioned high order.

Phase 8

6 rounds at 4000 yards into water

Serial No.	Type of Function
17834	H. O. on water
17824	H. O. possible on beach
17999	FTF not observed to strike
18052	FTF splash observed
17925	FTF " "
17955	H. O. on water

The extreme sensitivity, shown in Phase 2, would make the round unsafe for firing through brush or rain. Consequently, a new program is planned in which various methods for controlling the sensitivity of the "potted lucky" element will be examined. If the sensitivity is found to result from the thin cap it may be sufficient to thicken the cap, but if the detonation is caused by shock some type of absorbing material must be incorporated into the nose element assembly.

Future Program

(1) To determine shock sensitivity -.020 in thick cap.

a. Fire 5 rounds with protective covers over present potted lucky for graze functioning against earth at ranges of 250 ft to 1000 ft.

b. Fire 5 rounds with protective cover over the present potted lucky nose cap against .0045 in. thick Kraft paper at 400 ft. range.

(2) To determine the effect of increased nose cap wall thickness on fuze sensitivity using .060, .050, .040, .030, or .020 in. thickness caps.

a. 5 rounds for graze functioning at 200 - 1000 ft.

b. 5 rounds for impact functioning against 1" thick pine board.

c. 5 rounds for impact functioning against 1/2" thick pine board.

d. 5 rounds for impact functioning against chip board paper.

e. 5 rounds for impact functioning against .0045 Kraft paper.

(3) Evaluate the rounds equipped with nose caps having best wall thickness resulting from program (2).

a. 20 rounds for impact functioning on earth at 1000 yard range.

b. 10 rounds for impact functioning on earth at 2000 yards.

c. 20 rounds for impact functioning on earth at 4000 yards.

d. 10 rounds for impact functioning on water at 4000 yards.

If program (1) indicates that the rounds with .020 thick caps can be shock initiated then the test should be repeated with .060 thick nose caps.

If program (1) shows that rounds with .020 thick nose caps are not initiated due to shock then program (2) should be fired to determine the effect of increased thickness of nose cap material on sensitivity.

If program (1) indicates that both .020 and .060 nose caps are shock sensitive the test should be discontinued and the program revised to include a study of shock mounting the "Lucky" element.

The firing of all of program (2) will be determined by the results of parts a, b, and c, for any nose cap thickness i.e., part c will be tried only if part b functions, etc.

Program (3) will be fired if the results of program (2) are favorable.

It is suggested that when a proper nose cap is selected on the basis of 1 in. and 1/2 in. pine board, that 10 rounds be fired to evaluate the standards by firing in heavy rain, light foliage, etc. It is also desired that 10 rounds be fired without the bleeder (R-C) washer in the fuze circuit to check the tendency to premature.

MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contract DA-33-019-ORD-1202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated. Firestone's Defense Research Division, in shipping these items, transfers custody and control of the items to the receiving agencies. However, personnel of Defense Research Division will continue to collaborate with personnel of the other installations.

I. Cartridges, HEAT, 106mm, M344 (T119E11) Without Fuzes T208E7

Prior to	May 1, 1954	16,715	All Shipments
	No Shipments in May		

II. Rifles, T170E1 for ONTOS

Prior to	May 1, 1954	120	All Shipments
	May 13, 1954	9	Aberdeen Proving Ground
	Total	129	

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	May 1, 1954	22	All Shipments
	May 25, 1954	4	Allis-Chalmers

IV. BAT Systems less Jeep, T170E1 (M40) Rifle, T149E3 (M79) Mounts (with latest modifications).

Prior to	May 1, 1954	25	All Shipments
	No Shipments in May		

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